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EMANUEL SWEDENBORG'S  
INVESTIGATIONS IN NATURAL SCIENCE  
AND THE BASIS FOR HIS STATEMENTS CON-  
CERNING THE FUNCTIONS OF THE BRAIN



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on the occasion of the bicentenary of the Royal Society of Sciences of Uppsala  
and of the unveiling of the sarcophagus of Emanuel  
Swedenborg in the cathedral of Uppsala.

November 19<sup>th</sup>, 1910.

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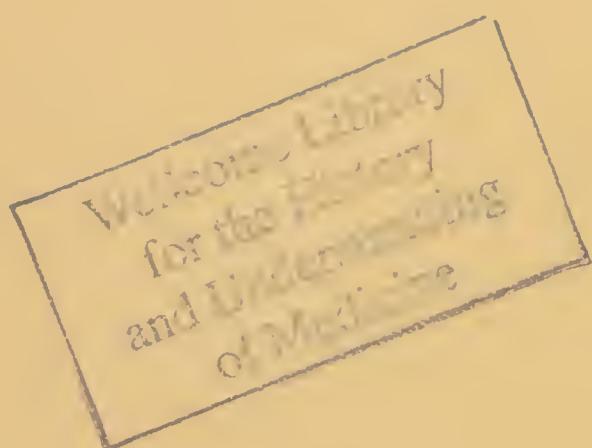
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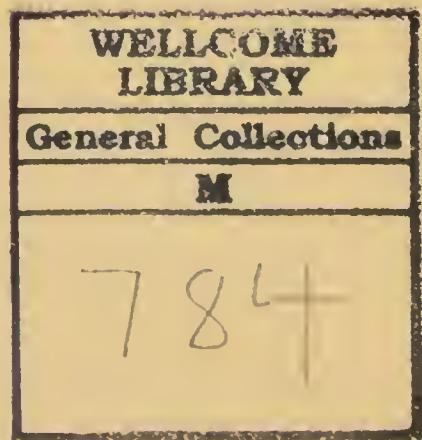
BY  
MARTIN RAMSTRÖM



UNIVERSITY OF UPPSALA  
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## CONTENTS

FRONTISPIECE, reproduced from a copper engraving in Swedenborg's »Opera Philosophica et Mineralia», Vol. I., printed in Dresden and Leipzig, in 1734.	Pag.
TITLE PAGE . . . . .	5
The vignette on the title page is reproduced from the medal struck in honour of Emanuel Swedenborg, in 1852, by the Royal Swedish Academy of Sciences.	
Introduction . . . . .	9
<b>Swedenborg's investigations in natural science.</b>	
Swedenborg's mathematical, mechanical and astronomical investigations .	11
Swedenborg's geological, mineralogical, chemical, physical, and cosmological investigations . . . . .	14
Swedenborg's anatomical and physiological investigations . . . . .	16
<b>The basis for Swedenborg's statements concerning the functions of the brain.</b>	
On the centres of the vegetative functions . . . . .	27
On the centres of the psychical functions, especially the sensory centres . .	28
On the centres of the motor functions . . . . .	32
The doctrine of localizations . . . . .	35
The »cerebellular theory» . . . . .	43
Concluding summary . . . . .	47
Notes . . . . .	50



# EMANUEL SWEDENBORG'S INVESTIGA- TIONS IN NATURAL SCIENCE AND THE BASIS FOR HIS STATEMENTS CONCER- NING THE FUNCTIONS OF THE BRAIN

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N RECENT TIMES EMANUEL SWEDENBORG has, on many sides, been the object of a continually increasing interest, and year after year has attention been called to the manysided works of his life. In former times he was known almost exclusively through his religious writings. But it has gradually come to light that he was also an investigating genius of the first rank, who opened new paths in several branches of the natural sciences and made wonderful discoveries.

Thus, by way of illustration, Professor ANDERS RETZIUS has drawn forth from oblivion his *anatomical* and *physiological* works and shown that there is to be found in them (especially in *'Regnum Animale'*) 'ideas belonging to the most recent times, and a scope, induction and tendency which can only be compared to that of Aristotle.'<sup>1</sup> And since then several authors have expressed themselves in a similar manner, as Professor CHRISTIAN LOVÉN,<sup>2</sup> Professor MAX NEUBURGER (Vienna),<sup>3</sup> Professor C. G. SANTESSON,<sup>4</sup> and above all Professor GUSTAF RETZIUS<sup>5</sup> on repeated occasions.

The case is also similar with respect to SWEDENBORG's *geological* researches. Here J. J. BERZELIUS<sup>6</sup> has sought to direct the attention of the learned to his penetrating observations and ingenious conclusions; and the opinions of such men as Professor A. E. NORDENSKIÖLD,<sup>7</sup> Professor

A. G. NATHORST,<sup>8</sup> and others, have also tended in the same direction in regard to SWEDENBORG.

Within the realms of *astronomy* and *cosmology* Professor M. NYRÉN<sup>9</sup> and later Professor S. ARRHENIUS<sup>10</sup> have pointed out the grand hypotheses of the creation of the worlds, etc. etc., which SWEDENBORG had erected in advance of all other authors in cosmology.

A number of societies and associations have also been formed whose purpose it is to spread a knowledge of SWEDENBORG's works concerning natural science. The oldest of these is the Swedenborg Society of London, which absorbed the purely scientific Swedenborg Association half a century ago, and which this year celebrated the centenary of its foundation. In 1898 there was founded in the United States of America the Swedenborg Scientific Association. In Sweden the Royal Academy of Sciences appointed in 1902 a committee to investigate the contents of SWEDENBORG's manuscripts and to publish selected works.

A number of individuals besides those already mentioned have devoted much labour and care to the translating and editing of SWEDENBORG's scientific works, among whom we may mention the Englishmen J. J. GARTH WILKINSON, M. D., and the Rev. A. CLISSOLD, the German Prof. Dr. IMMANUEL TAFEL, the German-American Dr. RUDOLF TAFEL, and the American Mr ALFRED H. STROH, M. A.<sup>11</sup>

The strongest expression of this interest in SWEDENBORG's scientific work in the most recent times, was that manifested during the International Swedenborg Congress, held this summer in London. On that occasion were gathered there representatives for numerous branches of the natural sciences, medicine, philosophy and theology, each one of whom contributed his account of the discoveries, inventions, and far-sighted utterances which SWEDENBORG had made within these several departments of knowledge. And imposing indeed was the homage which was as a consequence paid to the ingenious investigator as well as to the Country and the University which had produced him.

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## SWEDENBORG'S INVESTIGATIONS IN NATURAL SCIENCE.

BEFORE a life-work such as that of EMANUEL SWEDENBORG one cannot but be filled with admiration. Perhaps not so much on account of the *manysidedness* of it; for that was not so very unusual at the time in which SWEDENBORG lived — in the 18<sup>th</sup> century;<sup>12</sup> but because his researches were at the same time so *comprehensive* and *pene-trating*, because he made such great and important conquests within the most different departments of knowledge; indeed, in many places discovered by his sharpsighted genius the *lines of development* along which science was to proceed for the gaining of its end.

### SWEDENBORG'S MATHEMATICAL, MECHANICAL AND ASTRONOMICAL INVESTIGATIONS.

*Mathematics*, especially geometry, algebra and mechanics, and *astronomy* in particular, were the predominating interests with SWEDENBORG, when, after having completed his university studies, he entered upon his first foreign journey (1710). He had at that time the good fortune to come into personal contact with (ISAAC NEWTON?),<sup>13</sup> JOHN FLAMSTEED<sup>14</sup> and EDMUND HALLEY<sup>15</sup> in England, and with the renowned mathematicians PHILIPPE DE LA HIRE and PIERRE VARRIGNON<sup>16</sup> in France, and to enter into an interchange of scientific ideas with them. And the impulses derived from teachers of such great insight and skill did not take long in manifesting themselves. In 1714 SWEDENBORG was able to

send home accounts of a great many *mechanical inventions* which he had made and the »correctness of which he proved by mathematical and algebraical calculations.»<sup>17</sup> As examples of these discoveries may be mentioned his flying machine,<sup>18</sup> submarine boat, steam engine, mitrailleuse, sluice constructions, etc.<sup>17</sup> After his return to Sweden he found opportunities of putting into practice some of these projects, when (in 1716) he was appointed assessor extraordinary in the College of Mines and ordered to assist CHR. POLHEM »with the construction of his buildings and inventions». But he was rich in ideas and quick-witted enough to be able, together with these official duties, to plan and set on foot the publication of a periodical devoted to natural science, »*Daedalus Hyperboreus*», the first scientific periodical in Sweden, and to furnish it abundantly (during the years 1716—1718) with valuable articles concerning new inventions, *projects and problems for scientific investigations and experiments.*<sup>19</sup> In the year 1718 he has completed a new method of reckoning with the number 8 as the base; and the following year he publishes a still better »Proposal to divide our money and measures, so that the calculation would be easy and all fractions be abolished», and this system is nothing less than the *Decimal system!*<sup>20</sup> He also published during these years an ingenious method of determining the longitude by means of the moon, a problem upon which the learned had at that time been engaged for several years.<sup>21</sup>

SWEDENBORG thus succeeded in penetrating very deeply into the mathematical and mechanical sciences, and therefore at first it must arouse astonishment that he did not accept the professor's chair in mathematics at Uppsala University when this was offered him. He wished for freedom to study in other departments also. And, as we shall see, he soon turned his interest in another direction, namely to geology.

However, it was also a characteristic in SWEDENBORG, worthy of admiration, that in spite of his deep penetration into the sciences and the bold ideas of his creative genius, he nevertheless strove, at the same time, to retain contact with practical life and there cause the results of his investigations to bear fruit. It was also this purpose which to a great extent influenced him not to accept the offered professorship in

mathematics, which he feared would force him into a direction too theoretical. In this respect there were, as some of his biographers have shown, several points of similarity between SWEDENBORG and his patron, King Charles XII., namely, »the unusual combination of the boldest imagination and a pronounced practical tendency«.<sup>22</sup> And as both were animated by the same »burning inclination for all that is great in thought and deed«, and by the same love of the fatherland, therefore, when these two men found one another, there was an interesting cooperation. Professor HOLMQUIST has given a very good description of this in his essay alluded to above, from which I shall here reproduce some extracts:

— — — »But SWEDENBORG had also in the course of his conversation with Charles XII. advanced several new proposals which won, in part, the King's approval. SWEDENBORG suggested the establishment of a company to promote the exportation of Swedish iron and tar (a suggestion later put into practice by the Iron Office), set forth his plan for an observatory in Uppsala and brought up for discussion the establishment of salt works in Sweden in order to help his country against the terrible dearth of salt during the war: all these ideas he also committed to writing in pamphlets: '*Om sättet för handelns och manufakturernas upphjelvande*', '*Memorial om Salt Siuderiers inretning i Swerje*' and '*Om nyttan och nödvändigheten af ett Observatorii inrättande i Sverige*' (preserved in manuscript in the Diocesan Library of Linköping).<sup>23</sup> Of the ideas just mentioned, it was in the first place the one on salt boileries which claimed the King's attention and which he commissioned SWEDENBORG to put into practice. It still remains, however, to mention the most remarkable of SWEDENBORG's projects. Through ERIC BENZELIUS he had come into possession of an old letter of Bishop HANS BRASK, in which the idea of a water way from the western coast straight across Sweden is expressed. SWEDENBORG, inspired by this, laid before the King the *suggestion for a canal from Göteborg through Lakes Vänern and Vättern to the Baltic*, which aroused the King's enthusiasm. SWEDENBORG was commissioned to investigate the possibilities for the realization of this gigantic undertaking. — — — Shortly after this we find him in Uddevalla investigating the possibility of establishing salt-works, in connection

with which SWEDENBORG at once set out to construct salt-pans and other apparatus better than those in use in the defective old salt-works at Strömstad. — — — We afterwards find him again at Trollhättan, Vänern, Gullspång and Hjälmaren examining the situation for the canal and locks and finding 'all to be possible and not of such great expense as had been supposed'. SWEDENBORG had passed over to the modern idea of an inland canal through Hjälmaren and Mälaren directly to Stockholm. » With justice it may be said that here he gives the impression of a very shrewd and energetic engineer, who possessed the power of turning his thorough theoretical education to practical use.

It may thus be clearly perceived, from everything I have referred to above, how comprehensive and penetrating were the researches of SWEDENBORG in the mathematical (and especially the mechanical) branches of science, and what fruitful discoveries had been made by his searching eye.

#### SWEDENBORG'S GEOLOGICAL, MINERALOGICAL, CHEMICAL, PHYSICAL AND COSMOLOGICAL INVESTIGATIONS.

SWEDENBORG's comprehensive interest now turned itself to new fields of work: to *geology*, *mineralogy*, *chemistry*, *physics* and finally to *cosmology*, without giving up his first subject, *mathematics*.

And he also now exhibited the same thoroughness as before, beginning with examinations, experiments and observations, partly original, but also collected from predecessors. For he says: »It seems to me that an infinite mass of completed experiments is a good ground to build upon, to make the trouble and expense of others serve one's end; that is to work with the head over that which others have worked over with the hands.» (See HOLMQUIST, Op. cit. and the letter from SWEDENBORG to ERIC BENZELIUS of May 2<sup>nd</sup>, 1720, in the edition of the Acad. of Sciences, I., p. 304).

The result of this period of labour SWEDENBORG embodied in a number of works, among which may especially be mentioned: »*On the Height of Water and the Strong Tides in the Primeval World. Proofs*

from Sweden.<sup>24</sup> SWEDENBORG here furnishes proofs that our North, in olden times, lay for the most part under deep water. And he based his deductions on a great many researches and sharpsighted observations, and wherever it was possible he tested the correctness of his conclusions by means of experiments. This is the work which J. J. BERZELIUS, A. E. NORDENSKIÖLD and A. G. NATHORST have praised so highly, and in some places it has been considered to be »one of the most ingenious contributions to the history of geology». SWEDENBORG also worked out during this period the great work: »*Miscellanea observata circa res naturales et praesertim circa mineralia, ignem et montium strata*», (printed in Leipzig 1722 and lately reprinted in the edition of SWEDENBORG's scientific writings of the Royal Academy of Sciences., Vol. I., 1907, pp. 59—191), and finally the gigantic work: »*Opera philosophica et mineralia*», (published in Dresden and Leipzig, 1734, in three large folio volumes). The last work contains among other things SWEDENBORG's cosmology, and it is here that he develops his famous *nebular theory*, which so closely reminds one of the theory worked out in later years by Kant and Laplace, that one strongly suspects that SWEDENBORG's utterances, in one way or another, lie at the bottom of it. Concerning this work much has been written during recent years, and therefore it may be sufficient here only to refer to the statements made in regard to it by Professor S. ARRHENIUS in his introduction to the above-mentioned edition of SWEDENBORG's writings, Vol. II., where he says: »If we briefly summarize the ideas, which were first given expression to by SWEDENBORG, and afterwards, although usually in a much modified form, — consciously or unconsciously — taken up by other authors in cosmology, we find them to be the following:

The planets of our solar system originate from the solar matter — taken up by BUFFON, KANT, LAPLACE, and others.

The earth — and the other planets — have gradually removed themselves from the sun and received a gradually lengthened time of revolution — a view again expressed by G. H. DARWIN.

The earth's time of rotation, that is to say, the day's length, has been gradually increased — a view again expressed by G. H. DARWIN.

The suns are arranged around the milky way — taken up by WRIGHT, KANT and LAMBERT.

There are still greater systems, in which the milky ways are arranged — taken up by LAMBERT.<sup>25</sup>

During this period of his investigations SWEDENBORG enters into very deep speculations. He desires to grasp the innermost constitution of things, their causes and origin, and seeks to attain this end through a long process of analyses and by applying a geometrical explanation to the phenomena in the world of the senses. This method he employs in explaining the inner constitution of chemical bodies, and likewise the varieties of physical phenomena, etc. He thus comes at last to the — geometrical points: through the combination of these, in different ways, have all things of the universe originated in a mathematically definable manner; and the motion of these points is the all connecting, life-giving power.<sup>25</sup>

### SWEDENBORG'S ANATOMICAL AND PHYSIOLOGICAL INVESTIGATIONS.

After SWEDENBORG had so thoroughly searched through and speculated upon inorganic nature, he turns himself to the *organic*. He breaks away from all other work, travels abroad, and throws himself with intense zeal into *anatomical* and *physiological* studies. These researches were, for the most part, carried on in the Netherlands, France, and especially in Italy, where he remained for nearly a year.

After five years he was ready with his first work in this field, the large, famous, »*Œconomia Regni Animalis*,« which was printed in Amsterdam, 1740—1741. It was then published in two large volumes; but that it was designed to be still larger, is evident, among other things, from SWEDENBORG's own statement;<sup>26</sup> and furthermore, the Englishman J. J. G. WILKINSON published, in 1847, as a third volume, some

annotations which he regarded as belonging to SWEDENBORG's manuscript of the same work.<sup>27</sup>

The »*Economia Regni Animalis*« is chiefly directed to a detailed analysis of the *blood*, the *brain*, and finally the *soul*. In this investigation SWEDENBORG directed his attention not only to the morphological and physiological aspects of the subject, but also to the *embryology* of the organs; and he penetrated so deeply into the very essence of development, that, as Professor J. A. HAMMAR (Uppsala) has pointed out, he succeeded in arriving at a conception on this point, which was considerably better than that of his times. As is well known, during the first part of the eighteenth century the idea was generally prevalent that, when the organism developed from the egg or sperm, it grew forth out of it, much like a flower develops out of the bud, or, in other words, that the different organs existed pre-formed in the egg or sperm and that development consisted only in an extension of its size. SWEDENBORG expressed himself very decidedly against this »pre-formation theory«: The development consisted by no means merely in a growth or expansion of the germ, (»seminis extensio«), or of a prototype of the future creature existent in the germ, (»non . . . aliqua realis effigies maximi in minimo, seu in aliquo primo typus futuri corporis, qui simpliciter expanditur.« See *Ec. R. A. I.*, No. 249); but there was in the germ a certain formative substance or power, by means of which the various parts of the embryo were developed one after the other, organ after organ. (». . . singula membra successive, seu unum post alterum producuntur . . . . Ec. R. A. I., No. 247).

It will be seen that SWEDENBORG has here put forth essentially the same theory as was later presented by CASPAR FRIEDRICH WOLFF in his well known »Doctorsdissertation« of the year 1759, *i. e.*, the so called *theory of epigenesis*.

I shall here also discuss some of the results and conclusions, which SWEDENBORG arrived at in the »*Economia Regni Animalis*«, concerning the *brain* and *its function*.

As is well known the general principles of the macroscopical anatomy of the brain were known long before SWEDENBORG's days; and even

its microscopical structure had, half a century before his time, begun to be studied by such men as LEEUWENHOEK (1632—1723), MALPHIGI (1628—1694), and others. For example, it was not only known that the substance of the brain, upon incision, exhibits an outer, greyish layer, the cortex, and an inner, more pure white mass, the medullary substance; but the above-mentioned investigators had also shown that *the cortex of the brain* consists of a numberless mass of small globular bodies, which are closely surrounded by blood-vessels and are continued in small thread-like extensions, which run into the medullary substance.<sup>28</sup> Now SWEDENBORG succeeded, as regards *these globular bodies*, in arriving at the conception that they are *the most important components of the cortex* and that it is in these bodies that the nerves originate.<sup>29</sup> He called them »*Sphaerulae*» or »*Cerebellula*».

Again, as regards the *medullary substance*, it was already known through the works of WILLIS (1622—1675), VIEUSSENS (1641—1716), BOERHAAVE (1668—1738), that it consists, for the most part, of a great mass of finer and coarser nerve-fibres, and that these, through the medulla oblongata,<sup>30</sup> continue down into the spinal cord, and that through the nerves they are in communication with the various parts of the body. The nerves were supposed to contain a lumen, thus being tubular. On the basis of certain *clinical experiences* concerning the changes which occur in the functions of the soul, when the cortex of the brain is injured, SWEDENBORG succeeded in drawing the conclusion that the *same* medullary fibres which are derived from the »*Cerebellula*» of the cortex of the brain, continue into the spinal cord and are in connection with the nerves, and that thus an easily transmitted and continuous communication is established between the substance of the cerebral cortex and all the parts of the body, where the nerves are distributed.<sup>31</sup>

Concerning the *function* of the brain, the old view of HIPPOCRATES that the brain was a gland was still entertained in SWEDENBORG's time. The cortical substance served for secreting the »*spiritus animalis*», that is, what the ancients called the »*spirits of life*», and these were collected in the cortex of the brain that they might, when necessary, stream out through the nerves. The medullary substance was, according to the

latest conceptions of that day, the origin and source of the soul's activity, and the 'spiritus animalis' served as the connecting link between the soul and the sense-organs and muscles of the body.

SWEDENBORG also supposed that such a very easily flowing nervous fluid, 'fluidum spirituosum', communicated the impressions of the senses and the impulses of motion: but this fluid determined the connection between sense-organs and muscles on the one hand, and the *cortex* of the brain on the other. It was thus *the cerebral cortex!* to which the impressions of the senses were carried, and from this the voluntary impulses were sent out to the muscles. The cortex was thus the seat of both the sensory and motor activites of the soul in the body. *Œc. R. A.* III., No. 133: 'Substantia enim corticalis est ipsum cerebrum, seu sensorum et motorium commune.'<sup>32</sup>

But SWEDENBORG was not contented with this general idea of the cortex as the seat of the sensations and the will. He also drew conclusions from his previous experience and results regarding the continuous connection between the elements of the cortex and the ends of the nerves distributed in the various parts of the body.

On the basis of this connection he ascribed to the 'Cerebellula' a very important rôle in the activity of the brain. In the first place they received, through the external sense-organs and nerves, impressions from the outer world and worked them over: they were a kind of *inner sense-organs*.<sup>33</sup> And since the sensory impressions were so richly various as well in kind as in degree, the 'Cerebellula' must also possess various individual qualifications corresponding to these various sensory impressions. They were, at the same time, connected with one another, and so arranged into superior and inferior groups that they could receive and work over the various kinds of sensory impressions.<sup>34</sup>

There were also other groups of grey substance in the interiors of the brain, through which the sensory nerves passed; but all sensory impressions must ultimately be gathered together in the cortex of the brain so as to become conscious perceptions.

(Thus, for example, SWEDENBORG describes the optic thalami as such a secondary centre in the course of the path of sight;<sup>35</sup> and the

corpora striata in the path of the sense of smell;<sup>36</sup> and the origin of conscious tactile sensations he describes thus: — — — »rudior quicunque *tactus a superficie totius per medios nervos in Medullam Spinalem aut Oblongatam et abinde in activissimum cinerem, et in circumfusum corticem Cerebri emicet: Adeo ut extremi receptus modorum sint in cortice Cerebri, qui conscius redditur mutationum in seriebus et substantiis compositis usquam contingentium.*» (Ec. R. A. II., 192).

Thus: although SWEDENBORG did not suppose the »Cerebellula» to be arranged into sensory centres in the same manner as we do, still he seems to have supposed an arrangement something resembling this, with *Cerebellula-groups* as *subdivisions of the great sensible centre-organ, which is formed by the »Cerebellula» of the brain cortex, taken together,* and which Swedenborg called »Sensorium commune.»

In regard to the relation of the cortex to *motility*, SWEDENBORG expresses himself much more definitely. This activity of the brain SWEDENBORG also regarded as derived from the small cortical elements, the »Sphaerulae» or »Cerebellula». <sup>37</sup> He ascribes to them, on the one hand, a high degree of *self-determination*, so that they could perform their functions independently of each other, this on the basis of certain anatomical conditions, such as their position in respect to each other in separate cavities, and their connection each with its own special nerve-fibre, and, besides, also on the basis of certain clinical and pathological observations;<sup>38</sup> but on account of other anatomical conditions, such as the aggregation of the »Cerebellula» into larger and smaller groups, as into gyres, and groups of gyres, etc., as well as on certain other grounds, he ascribed to them also the ability to *cooperate with each other* when necessary.<sup>39</sup> In consequence of this the brain possesses, as he says, the power and choice of influencing whatever nerves and muscles it will, and of stimulating them to activity. (»Proinde Cerebri secundum ordinatam ejus substantiae dispositionem in potentia et arbitrio est, quascunque velit fibras, aut fibra- rum fasciculos, et consequenter nervos et musculos inspirare et ad agen- dum excitare.» (Ec. R. A. II., 153). It was impossible for him to ex- press himself as to what parts of the cerebrum or which convolutions,

*gyri, correspond to the respective muscles, but he refers to experimental investigations of animals, by which this might be discovered.*<sup>40</sup>

But although the brain would then be able to govern every muscular action, it was not employed every time such an action was to be performed. No, in the medulla oblongata and in the grey substance of the spinal cord there were *subordinate, secondary motor centres*, and these governed the automatic and habitual movements, so that, for the performance of these, the brain need not be disturbed in its higher functions. Only for the purely voluntary motions were impulses from the cerebrum necessary.<sup>41</sup>

SWEDENBORG has thus clearly located the »*causa principalis*« of the voluntary movements in the *cortex of the cerebrum*, or more definitely, in the *cortical elements and in groups of such elements*, although in this work »*Œconomia Regni Animalis*« he did not succeed in more closely defining the position of the various motor centres.

From all that I have here brought forward concerning the functions which SWEDENBORG ascribes to the cortical substance of the brain, it is evident that he succeeded in coming to the full conviction that it is *through the activity of the »Cerebellula»* (or as we express it, through the cerebral nerve-cells) that *the perception of sense-impressions and the impulses to voluntary motions arise*.

But SWEDENBORG does not stop even here. The elements of the cerebral cortex, he continues, are still not the ultimate determinants. They are only, so to speak, the inner sense-organs<sup>42</sup> and sub-determining media.<sup>43</sup> They are themselves subordinated under the understanding and the will, and their principle, the soul.<sup>44</sup> The soul, the principle of life, it is the soul, which, through those cortical elements, perceives the external world: it is the soul which feels, sees, hears, smells, tastes, it is the soul which recollects, thinks, performs, and wills; it is the soul which speaks and acts.<sup>45</sup>

What then is the soul, and where does she reside?

The seat of the soul must surely lie in the cerebral cortex; at least its activity comes into play there, and still more definitely, in the »*Cere-*

bellula» of the cortex. (See above and also »The Brain», No. 7). But what is she? What is the soul?

Here SWEDENBORG makes one attempt after the other to draw away the obscuring veil. Sometimes he thinks of the soul as only dwelling and working in the »Cerebellula» and their »fluidum spirituosum»; but in this way he does not come to a solution of the principal question, which is only removed farther away.<sup>46</sup> Sometimes he thinks the soul to be identical with the »fluidum spirituosum»; but how can this, however subtle fluid, be immortal? Here he is again repulsed.<sup>47</sup> He discusses the supposition that, although the »fluidum spirituosum» in itself is not immortal, it yet becomes so upon the death of the body, and so forth.<sup>48</sup> And at last he bursts out with: »it amounts to the same thing if we see in this fluid the soul itself, or only its faculty of imagination and judgment, for the one cannot be thought of without the other.<sup>49</sup>

SWEDENBORG himself, however, was not satisfied with the result, but acknowledges that he had been too hasty, when, after having in reality thoroughly considered only the blood and brain, he entered immediately upon the search for the soul. He therefore says in the preface to the next work: »I am now determined to allow myself no respite, until I have run through the whole field to the very goal — until I have traversed the universal animal kingdom to the soul (usque ad animam). Thus I hope, that by bending my course inward continually, I shall open all the doors that lead to her, and at length contemplate the soul herself: by the divine permission.»

It is grand to see the indomitable energy and zeal for investigation in this man of 53 years!

He was now obliged to extend considerably the field of his investigations — thereby to come to still more thorough insight into the conditions of the soul's life, and afterwards, as he says, »in his analytical way to be able to work himself up from the lower to the higher», to find the way from phenomena and facts to causes and the final principles of the organism's intricate mechanism.

Three years later he has ready the first two volumes of his new work, and the following year, 1745, a third volume. This work is the

›Regnum Animale›, (The Soul's Kingdom). It is constructed upon a very grand plan, comprising not less than 17 parts. Of these, however, only the three mentioned above issued from the press, and they treat of the organs of the chest, abdomen, and skin, and of the senses of touch and taste.<sup>50</sup> Professor IMMANUEL TAFEL (Tübingen) in the middle of the 19th century afterwards published two more volumes of the manuscript. The first of these, Pars quarta, treats chiefly of the senses of smell, hearing and sight and the higher degrees of the soul's activity; and the other, Pars septima, treats of the soul.<sup>50 b)</sup>

But simultaneously with the work in question SWEDENBORG wrote still another, namely, the great work on the brain, ›De Cerebro‹. — In these works SWEDENBORG reached *the summit of his scientific career*, and they afterwards served as the foundation of the religious edifice to which he devoted the remainder of his life.

The ›De Cerebro‹ of SWEDENBORG, just referred to, is a rather large work which treats of the brain from the anatomical, physiological, and philosophical standpoints. This work left by SWEDENBORG in Ms., has appeared in print only in part, namely, in the English translation by Dr. RUDOLF TAFEL, published in London in two volumes, 1882 and 1887, and entitled ›The Brain‹. Although this edition comprises, as was said, only a portion of the whole work, it treats of both the cerebrum, cerebellum and medulla oblongata, as well as of the cranium and the membranes of the brain, but chiefly only in so far as their structure and function regard the activity of the soul. Without doubt SWEDENBORG's main interest here centred on this subject, and therefore I shall give some intimations concerning how deeply SWEDENBORG has succeeded in seeing into the function of the cerebrum as the organ of the soul's life.

SWEDENBORG divided each hemisphere of the brain into an anterior and a posterior region, separated from one another by the fissure of Sylvius. Now, in *the anterior region* he located *the essential activity of the soul*, while as regards the posterior region, he supposed that it was chiefly active in animating the blood (›The Brain‹, No. 71). In the anterior region he furthermore distinguished *three lobes*, or, as he called them, ›curiae‹, in which the soul resided and exercised its functions (›The

Brain», No. 88). He does not define the boundaries of the lobes, but distinguishes them by saying that the soul's activity in the highest lobe attains to the highest degree of clarity and perfection, while in the inferior lobes, the middle and the lowest, the soul's activity successively decreases in sharpness and intensity! (»The Brain», Nos. 66, 88). In these lobes or curiae the essential psychic life also has its rise; here observations, thoughts, judgments, conclusions come into being, yea, even determinations and the utterances of the will proceed thence. Here consequently is the source of both the sensory and the motor functions of the soul (»The Brain», Nos. 88, 100).

As we have seen, SWEDENBORG had already shown, in »Œconomia Regni Animalis», not only that it is in the cortex, but just in *the cortical elements*, the »*Cerebellula*», that the brain's psychic function is performed. SWEDENBORG emphasizes the same idea in »De Cerebro», and declares that these »*Cerebellula*» are the units of which the brain is constructed, and from which its essential nature is derived (»The Brain», No. 34).

As in the »Œconomia Regni Animalis», so in »De Cerebro», he also refers to the arrangement into *different groups*, which is so important for the function of the cortical elements or »*Cerebellula*», and with respect to this he now makes a new statement, which is of such a nature as necessarily to excite amazement: he sets forth the most essential part of *the modern theory of localizations*. Word for word this statement reads as follows: »*The muscles and actions which are in the ultimates of the body, or the soles of the feet, seem to depend more immediately upon the highest parts (of the anterior region of the brain)*<sup>51</sup>, *the muscles which belong to the abdomen and thorax upon the middle lobe, those which belong to the face and head upon the third lobe; for they (the muscles of the body and the lobes of the brain)*<sup>51</sup> *seem to correspond to one another in inverse order*». (See »The Brain», No. 68). — Thus, the essential features of the modern doctrine concerning the relative positions of the motor centres in the cortex of the brain, that doctrine into which we have obtained an insight first after much comprehensive and complicated labour during the last century!

I shall no longer at this point continue the discussion of this work.

What I have brought forward may suffice to indicate the character of SWEDENBORG's investigation and the statements and discoveries based thereon. By his works on the brain SWEDENBORG reached the *summit* of his Scientific activity, but also its *conclusion*. He now passes over to the transcendental field. With the limits which we have set for our examination, we must, however, refrain from following the energetic investigator in his continued search for truth.

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## THE BASIS FOR SWEDENBORG'S STATEMENTS CONCERNING THE FUNCTIONS OF THE BRAIN.

If we take a general view of SWEDENBORG's investigations, the outlines of which have been sketched above, a number of questions are suggested: Whence did SWEDENBORG secure the material for all these farsighted statements, whence the evidence for all these discoveries? Did SWEDENBORG himself carry out the special investigations which must have formed the basis of his beautiful results?<sup>52</sup> Or was the evidence ready at hand in the literature of those days?

The answering of these questions is naturally of a certain importance in the valuation of the opinions expressed. And as several of SWEDENBORG's statements concern questions which are still among the »unsolved», I have taken up some of these questions for examination. In this I have restricted my investigation to a confined province, and chosen one which in our own times is of great actual interest, namely, the function of the brain, and especially that of the cerebral cortex. As we have already seen, SWEDENBORG connected in the closest manner the soul's activity with the cortex of the cerebrum, indeed, he localizes in detail special departments of that activity to determinate regions of the cortex; and the object of my investigation is, therefore, to endeavour to find out upon what foundations SWEDENBORG erected this doctrine of the centres of the psychic functions in the cortex of the cerebrum.

## ON THE CENTRES OF THE VEGETATIVE FUNCTIONS.

With regard to the function of the brain, SWEDENBORG, in the first place, made the distinction that the cerebrum regulates the psychic, and the cerebellum the vegetative functions.

Many different opinions prevailed in SWEDENBORG's time concerning this question. Some investigators considered that the vegetative as well as the psychical functions stood under the direct control of the cerebrum; others that *the centres of vegetative life were separated from those of psychic life and had not, like these, their place in the cerebrum.* And SWEDENBORG adopted the latter opinion, primarily for the following reasons:

1) *Experiments on animals* had brought to light the fact that respiration and the action of the heart continued for a time even after the hemispheres of the cerebrum (in dogs) had been separated from their connection with the cerebellum and medulla oblongata, indeed, even if the hemispheres of the cerebrum (in dogs) had been extirpated.<sup>53</sup> He was also led to the same conclusion by

2) *Certain teratological and pathological anatomical experiences,* which he had gathered from his studies of books. He advances cases described by WEPFER, TYSON and RIDLEY, MANGET, KERKRING, MORGAGNI, and others, which showed that although the cerebrum had occasionally been entirely or in part missing in foetuses, yet these deformed foetuses could nevertheless live a shorter or longer time after birth. And in agreement with TULPIUS he calls attention to the great deformation of the cerebrum in the case of hydrocephals. In close connection with this he gives accounts (from VALLISNIERI and others) of extreme cases of petrifications in the brain, regarding which one must suppose that when the cerebrum gradually lost its functions and the vegetative vital functions nevertheless continued for a time, these must then have been regulated by the remaining parts of the central nervous system, that is, by the cerebellum, medulla oblongata and the spinal cord. (See Œc. R. A. I., Nos. 573, 574 *et seqq.*).

From these experiments and discoveries it was thus evident to SWEDENBORG that the centres for vegetative life are not to be sought for in the cerebrum.

As was said, he located them instead in the cerebellum, and the reason for this seems in brief to have been the following: MANGET and VIEUSSENS had described a number of experiments on animals which were said to have proved that after lesions of the cerebellum respiration and the action of the heart at once ceased.<sup>54</sup> The injuries in these experiments had evidently extended more deeply than the descriptions recount, by which the false conclusion in regard to the cerebellum is explained. It was probably because of such misleading experiments as these that SWEDENBORG's highly esteemed contemporary, HERMANN BOERHAAVE, (1668—1737), held the same opinion that the vegetative vital functions are regulated by the cerebellum.<sup>55</sup> However, the Englishman THOMAS WILLIS, (1622—1775), had come nearer the truth, when, in a very guarded statement, he connected these functions with both the cerebellum and the medulla oblongata.<sup>56</sup> And when SWEDENBORG chose his position on the question he seems to have been influenced by both of these authors, and received the opinion that the cerebellum was the main centre of vegetative life, making, however, the important addition, that the medulla oblongata, as for that matter also the spinal cord, are secondary centres, subordinated to the cerebrum and cerebellum.<sup>57</sup> This addition was based upon a conclusion which SWEDENBORG had drawn, among other things, from the teratological and pathologic-anatomical observations and from comparative anatomy, but there is no occasion for entering into this more closely in this connection.

After SWEDENBORG had, however, upon the grounds alluded to, separated the centres for the vegetative life-functions from the cerebrum, there lay before him the localization of the psychical functions; and, as to them, SWEDENBORG located the centres of the sensory portion of the soul's activity in the cortex of the cerebrum.<sup>58</sup>

#### ON THE CENTRES OF THE PSYCHICAL FUNCTIONS, ESPECIALLY THE SENSORY CENTRES.

That the sensory activity of the soul has its centres in the cerebrum was in SWEDENBORG's time considered quite certain, but it was not so

certain as to just what part of the brain it was in which the soul's activity arose.

It is well known that the philosopher DESCARTES ( $\dagger$  1650) had supposed that the *glandula pinealis* (pineal gland) was the seat of the soul, and that the conscious perceptions came into being in this gland and in the central ventricle of the brain, the »third ventricle«, from which the nerves, according to his opinion, took their origin.<sup>59</sup>

Gradually, however, there seems to have been more and more an inclination to attribute this phase of the operation of the soul to *the white, medullary substance* around the ventricles of the brain. And in SWEDENBORG's time this opinion seems to have been the usual one. At least the matter is so presented by HERMANN BOERHAAVE, who, as is known, in a high degree had the ear of his contemporaries.<sup>60</sup>

And even HALLER, some twenty years after SWEDENBORG had written his works on the brain, was still of a similar opinion, as is evident from a quotation which I shall here bring forward, in which he emphasizes that neither perceptions nor the impulses to motion arise in the cortex of the cerebrum, but in the medullary substance: »Non ergo in cerebri cortice sensus sedes erit, aut plena causae muscularis motus origo: eritque utraque in medulla cerebri, & cerebelli.» (ALB. V. HALLER: »Elementa physiologiae», Lausanne, 1762, Tom. IV., p. 392). But when even HALLER would not attribute the soul's activity to the cortex, what then can have led SWEDENBORG to such a thought?

In order to clear up this question let us first examine the *anatomical literature* before SWEDENBORG's time. And then we find that the BARTHOLINS had already in a kind of way associated this branch of the soul's activity with the cerebral cortex, because they supposed that the »spiritus animalis«, (the »spirits of life«), was contained in the cortex for the sensory functions, just as it was conserved in the medullary substance for the motor functions.<sup>61</sup>

And THOMAS WILLIS considered that the »spiritus animalis« was generated in the cerebral cortex, but afterwards underwent proper elaboration and distribution in the medulla of the cerebrum; and that the memory had its seat in the cerebral cortex.<sup>62</sup>

And MALPHIGI (1628—1694) had expressed the surmise, that the minute *cortical elements*, so particularly described by him, which correspond to what we now call the nerve-cells of the cortex, were small glands, 'glandulæ', whose function was to *prepare a substance which, conveyed through the nerves, calls forth perceptions.*<sup>63</sup>

It had also been shown by the researches of MALPHIGI that these 'glandulæ' put forth a vessel-like fibre, which continued into the cerebral medulla; and that this medulla for the greater part consisted of such fibres or vessels.<sup>64</sup>

In how far these structures were 'fibres' or 'vessels', and whether they proceeded from ('oriuntur') or terminated in ('desinunt') the small cortical elements, MALPHIGI leaves undecided. And when BOERHAAVE afterwards in his lectures on the brain describes these structures, he still depicts them as the finest tiny canals, which take up the 'spiritus animalis', pressed into them from the cortex, and transport it down to the medulla oblongata, whence it is afterwards, by means of the nerves, distributed to the different parts of the body. This 'spiritus' BOERHAAVE describes as elaborated in the cortex, 'fabrica mirifica corticis praeparatus'.<sup>65</sup>

These observations and surmises have evidently exercised a great influence upon SWEDENBORG's conception of the function of the cerebral cortex; but they alone could impossibly have aided him in reaching the enlightened standpoint at which he arrived. No, the most determining and decisive factor for him in this question evidently was a great mass of *clinical and pathological observations* which he had collected and synthesized, namely, symptoms of disturbances of consciousness and sensibility, which had been exhibited by such patients, who, as was shown by post mortem examination, had been injured in the cerebral cortex. And I shall later refer to some of these cases in connection with the consideration of the brain's motor functions, because these patients nearly always also exhibited motor disturbances.

But even here I may quote some of SWEDENBORG's own words, which will show what importance he attached to these testimonies: 'It is the cerebrum or the cortical substance in which the soul disposes and unfolds

its purest and most simple organic forms of activity, and what the cerebrum is, appears from a change of the faculties in some diseases, as in apoplexy, epilepsy, paralysis, etc., likewise in many morbid states of the animal mind in a cerebrum wounded by various accidents; (»The Brain», No. 86).

And in another place he says: »If the cerebrum is either inflamed or obstructed, or flaccid, or injured otherwise, the intellectual faculty is unsettled; as in paralysis, melancholy, in cases of delirium, in atrophy, apoplexy, in fevers, and other diseases; nay, the determination of the will also is similarly affected. For each single cortical substance contributes its share to this intellectory, that is, to this organ of the understanding, etc. (»The Brain», No. 104, r).

All these observations concerning the consequences of injury to the cerebral cortex — and the above-mentioned discoveries regarding the structure of the cerebral substance and the hypotheses concerning the relation of the cerebral cortex and cortical elements to the »spiritus animalis» and the perceptions, — these *clinical* and *anatomical experiences taken together* seem to have led SWEDENBORG to the conviction that the activity of the soul and not least that just now in question, the sensory, had its seat in the cortex of the cerebrum.

He now enters into a detailed analysis of the course of the sensory nerves as far as they are able to be demonstrated (»in ipsius oculi luce»), and he thus follows the optic nerves to the optic thalami, and thence their radiation towards the cerebral cortex, the olfactory nerves to the corpora striata or the medulla of the centrum ovale and from there out towards its cortical surroundings, the auditory nerves to the medulla oblongata and thence up toward the cortex of the cerebrum, (»versus supremum corticem»), and in the same manner he follows the nerves of taste and touch. (See OEc. R. A. II., No. 192; and III., No. 66). He cannot now follow further the particular fibres through the medulla all the way to the cortex, of whose importance for consciousness and sensibility he became convinced through the clinical experiences, but here he must *suppose* a connection, and he says: »these effects (conscious perceptions) could never be produced . . . unless in every quarter there

were a mutual connection and perpetual communication of the cortical substance with the medullary, as regards the fibrils . . .», (as well as a special arrangement of the cortical elements and special qualifications in them, of which more will be said later).<sup>66</sup>

From all this it is clear, that it was probably through a combination of clinical and anatomical experiences that SWEDENBORG secured the premises for his conclusions that the centre of the soul's sensory activity is in the cortex of the cerebrum.

#### ON THE CENTRES OF THE MOTOR FUNCTIONS.

SWEDENBORG also placed the centres of the soul's motor activity in the cerebral cortex (See *Œc. R. A.*, No. 127, etc.).

I have not been able to find anything of this kind even hinted at in the antecedent literature. We are reminded of how preceding authors, who made an attempt at some kind of localization of the origin of motion, in most cases placed this in the medulla of the brain, as for example the BARTHOLINS;<sup>67</sup> and also BOERHAAVE.<sup>68</sup> And as we have just heard, HALLER still held the same view.<sup>69</sup> Nevertheless SWEDENBORG expresses his conception without the slightest hesitation, and this he did because he regarded it as resting on a sure foundation. His strongest grounds and proofs were here also derived from the *clinical and pathological observations* in certain cerebral diseases which had caused changes in the cortex, and in patients, who had been injured in the cerebral cortex. It was these clinical cases at which I hinted just now. And now some of these may be brought forward, for the most part as SWEDENBORG himself has related them — with some few abbreviations:

A female seventy years of age, who after exhibiting the premonitory symptoms of apoplexy for some months suddenly *lost the power of speech*, and on being conveyed to bed, lost all sensation and motion. On a post mortem examination a large cavity was found in the cortical substance of her brain (»in ejus Cerebri substantia corticali ampla cavitas resperta fuerit», see *Œc. R. A. II.*, No. 154). The case was taken from J. J. WEPFER'S »*Historiae Apoplecticorum*» (Amsterdam, 1681, pp. 5—11).

Another case taken from WEPFER was the following: A man 50 years of age had for some weeks before his death suffered from excruciating headache, the pain of which sometimes drove him mad, so that he was not seldom unconscious of what he said and did. On examining his head after death, the whole surface of the cerebrum and cerebellum, including both the convolutions and the furrows between them, seemed to be clogged all over with a gelatinous substance, from which, when it was pricked with a lancet, genuine serum oozed out. And also the very substance of the cerebrum and cerebellum had imbibed a large quantity of serum. (Œc. R. A., loco cit. and J. J. WEPFER: Op. cit., p. 15—19).

A case from A. PACCHIONI was as follows: A young man had died under symptoms of fever, severe headache and *spasms*, or *cramp*. On opening his cranium, it appeared that the firm fibrous membrane of the brain, the dura mater, was loosened from the bone on the top of the head; and here, according to the description, it had exercised a strong pressure upon the underlying portion of the brain and was tightly adherent to it. (Œc. R. A., loc. cit.) — — Consequently, in the last two cases: inflammation of the membranes of the brain, or meningitis with accompanying influence upon the superficial layer of the brain, the cerebral cortex.

And still another case from PACCHIONI, which was still more convincing: A youth was brought into the hospital in an almost unconscious condition, spoke incoherently, cast himself about in all directions, etc.; and furthermore — — his *lips were somewhat drawn over to the left side* (»*labris ad sinistrum paululum detractis*«), thus a right-sided *facial paralysis*! On examination after death no injuries could be found upon the integuments of the head, nor upon the outer or inner sides of the cranium, but on the left side of the brain *a depression of the cortex* was discovered, occasioned by the formation of a tumor or »bladder« on that part of the surrounding dura mater lying just over the place of depression: »*ibi de pressus et durioris consistentiae cortex cerebri cavernam ostendebat vesicae congruentem.*«<sup>70</sup>

SWEDENBORG brought forward still more cases, so incomplete, however, that it is not worth while to repeat them here. But he had at hand a very large number of cases, as he says: »*phalanges observationum*

idem testificantium» (Œc. R. A. N:o 154), or, as he says in another place, so many that a bare enumeration of them would fill two whole pages (Œc. R. A. II., 154).

SWEDENBORG had made a specially careful study of a great many cases of *apoplexy* and *hemiplegy*, which naturally, in so far as they affected the cortex, gave him direct guidance in judging of its function. And he also understood very well how to judge at the same time with regard to the importance of bleedings in the soft membrane of the brain, the pia mater, on and between the convolutions of the brain, the »gyri», and the pressure that these exercise upon the cortex, and the results of prevented circulation in cases of apoplexy. For in all these cases, he says, the transmission of blood to the cortex is checked, and by this the cortex was disturbed in its function, and this was the cause of the loss of sensation and of the paralysis. (Œc. R. A., III., No. 411 and III., No. 413; see also »The Brain», No. 89).

But SWEDENBORG had also directed his attention to that method of investigation which, to the brain physiologists of the present day, is the best aid for the examination of the motor functions of the cerebral cortex, namely, *experiments on animals*. He quotes such experiments, in which *incisions* had been made into the cortex »just to the marrow», as it is expressed, (»usque ad substantiam medullarem» [RIDLEY], Œc. R. A., I., No. 505); or when the brain (in dogs) had been *pierced*, (Œc. R. A., II., No. 154), and how these injuries had occasioned spasms or contractions of the trunk or extremities (RIDLEY). He also describes such cases in which fine needles had been pierced through the dura mater and corrosive liquors introduced through the holes, with the result that severe disturbances occurred in both motility and sensibility, and also how through such injuries muscular contractions had been provoked, by which it was sometimes observed that with certain stimuli the contractions first occurred in certain groups of muscles (for example, in the head or neck) and afterwards spread to the other parts of the body. (BAGLIVI »The Brain», No. 20).

As will be seen, these experiments were no »precision-investigations»; and the same may be said of the clinical and pathological ones.

And this may be the more easily understood, when we consider that in those times so much interest was not attached to such special observations of pathological changes in the cerebral cortex; for this was then regarded only as a gland, a secreting organ or reservoir for the *'spiritus animalis'*. These observations were therefore made more as it were in passing. The same is also true of the experimental investigations on animals, quoted above. These were in reality made not in order to investigate any function of the cortex, but for other purposes, namely, in order to search out the causes of the pulsations of the brain, or the qualities and functions of the dura mater, etc.

Yet, as we shall see later on, some of the cases, in the original descriptions, really contain statements somewhat more exact and of greater interest even for the theory of cortical localizations, than those which SWEDENBORG quoted; but he seems to have here adduced no more than what had reference to the *cortex regarded as a whole*, and which showed what great changes in both the power of sensation and motion injuries in the cortex could produce. If we take this into consideration, and if we synthesize all these experiences, and add to this the increased knowledge concerning the minute structure of the brain, which had been produced especially by MALPIGHI's discoveries, we must admit that SWEDENBORG had good reasons for his view that the soul's activity had its seat in the cortex of the cerebrum.

### THE DOCTRINE OF LOCALIZATIONS.

But SWEDENBORG, as is well known, did not stop here. The cerebral cortex certainly constituted a whole which transformed the sensations into thoughts and determinations, but all the regions of the cortex were not of the same degree: some ruled the higher, others the lower functions, thus also containing subdivisions, in some of which the sense-impressions were received, in others from which the motor impulses proceeded. (See *'The Brain'*, Nos. 66, 68, 71, 88, 98, 100, 102, etc.).

This conception of the brain appears at first glance as very modern. But upon searching the literature before SWEDENBORG's time one finds

that the thought was not so entirely original. New was the thought of attributing the psychical functions to the cortex, new also was the attempt to accurately determine upon the place where the different functions originate; but the *idea of localization* itself is found again in the literature which SWEDENBORG already had at his disposal.

BOERHAAVE, for instance, says, in his *»Institutiones medicæ«*, when speaking of the sensations, that they give rise to *different perceptions*, partly owing to the differing species and nature of the outer objects, and partly to the different natures of the sense-organ and the affected nerve, but partly also to *the different regions in the cerebral medulla from which the nerve proceeds*. Thus we have here a kind of localization to a special region of the brain, although in its *medulla*.<sup>71</sup> And still more clearly does BOERHAAVE express the same idea in his *»Prælectiones academicae,«* where he says: »In the 'Sensorium commune' there are *regions locally distinguished for the different senses, just as every sense has its own special sense-organ.*«<sup>72</sup>

And before BOERHAAVE the philosopher DESCARTES had expressed an idea concerning a certain form of localization of the various elements of psychic activity. For he supposed that the images of sensation and the images of the memory, etc., which the soul perceives, arise on those places on the walls of the brain's central ventricle, where, according to his opinion, the various nerves originate. In a similar way he also imagined the origin of motility localized. (R. DESCARTES: *»De homine«*, publ. by F. SCHUYL, Ludg. Bat., 1662).

We here reproduce some illustrations from the work of DESCARTES just mentioned, which are designed to show how he thought that the images of sensation arise. — — See the figures 1, 2, 3.

We thus see that the idea of localization itself was not altogether new. But how did SWEDENBORG ultimate and develope it?

With regard to function SWEDENBORG divided the hemispheres of the cerebrum into two parts: one anterior region and one posterior, conceiving the fissure of Sylvius as the dividing boundary between them. (*»The Brain,«*, Nos. 16, 88, 91).

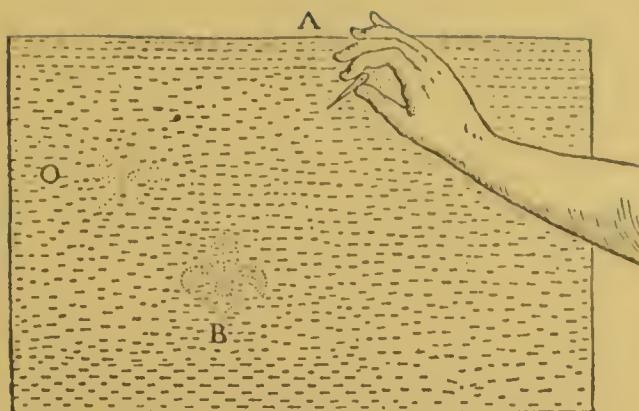


Fig. 1.

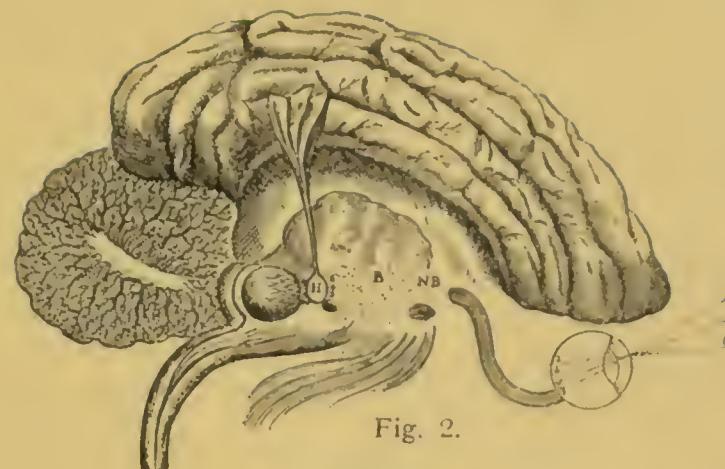


Fig. 2.

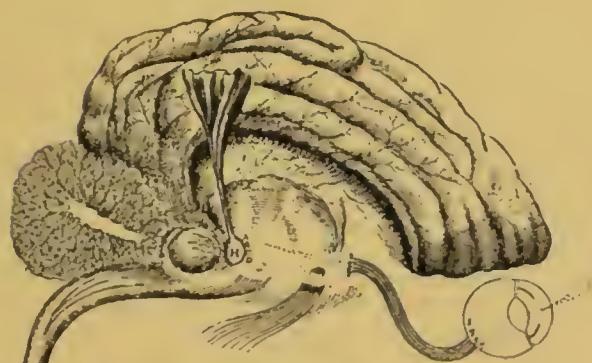


Fig. 3.

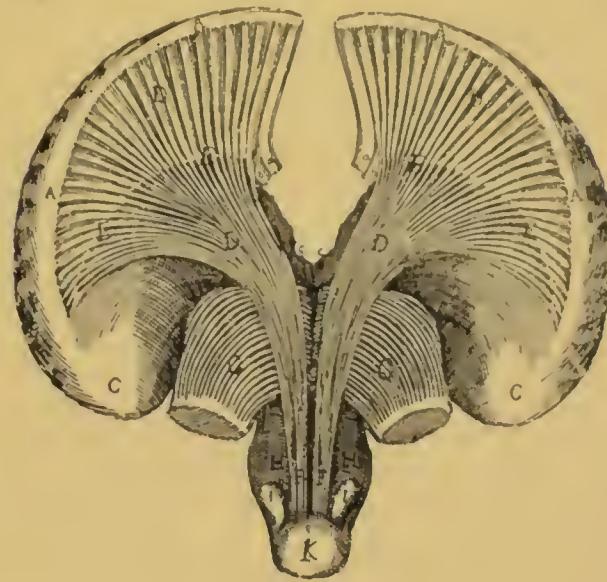


Fig. 4.

Figures 1—3. Reproduced from Descartes: »Tractatus de homine».

- Fig. 1. A part of the wall of the central ventricle of the brain. The points of the dotted area represent the openings of the nerves, which, according to the opinion of Descartes, take their origin in the wall of the ventricle. The figures O (star) and B (lily) are formed by combinations of such nerve openings.
- Fig. 2. View of the left hemisphere from the medial side. The dotted area B represents the place, where, according to Descartes, the nerves originate. The vesicle H is the pineal gland, wherein the soul was thought to have its seat.
- Fig. 3. Illustrates the act of seeing. The object ABCD forms an image, 1357, on the retina of the eye. This image provokes a similar image, 2468, on the wall of the brain's ventricle, by exciting a stream of »spiritus animalis» from the central ventricle through certain of the fine nerve tubules of the optic nerve, the openings of the nerve tubules in the wall of the ventricle being widened and thus forming images (of sight), which the soul is able to perceive from its seat in the pineal gland.
- Fig. 4. Reproduced from Vieussens: »Neurographia universalis», Tabula XVI. Illustrates the passage of the coarse fibres of the *middle region of the brain's medullary substance* through the capsula interna, pons and the pyramids on the front of the medulla oblongata downwards to the *anterior part of the spinal cord*.



To the anterior region he attributed the actual operation of the soul, while he supposed that the posterior region was chiefly engaged in the animation of the blood. He adds, however, »it cannot be denied that sensations reach even the posterior region of the brain, yet our mind does not become conscious of them to the same degree as it does in the anterior region» (»The Brain», No. 71).

In this *anterior region of the cerebrum* he distinguished *three lobes*, or so called »curiae», the first one highest up, »in the crown», a middle one below it, and a third one lowest down, *i. e.*, nearest to the fissure of Sylvius.<sup>73</sup> In these three lobes the actual psychic life is developed, and that so much the more clearly and perfectly, the higher up in the region these intricate processes occur. It is here that perceptions, thoughts, judgments, conclusions, come into being; it is from here that ultimately will and determination issue. (See »The Brain», Nos. 12, 66, 71, 88, 98, 100, 102).

As regards the sensory part of the psychic activity, SWEDENBORG does not make any attempt at a detailed localization; but as regards the motor functions he arranges their centres within the above-mentioned regions as follows: »*The muscles and actions which are in the ultimates of the body* or in the soles of the feet seem to depend more immediately upon the highest parts (of the brain), upon the middle lobe the muscles which belong to the abdomen and thorax, and upon the third lobe those which belong to the face and head;» and he adds, »for they seem to correspond to one another in an inverse ratio» (»The Brain», No. 68).

Whence did SWEDENBORG get all this? Whence the whole of this doctrine of localizations? In his first great anatomical work, »Œconomia Regni Animalis», nothing is said about it; first in his last anatomical work, »De Cerebro», is it advanced, and then — — — quite finished! One is at first glance tempted to think that he had succeeded in finding some new clinical experiences, upon which he could found this doctrine. For he had not even finished the account of the function of the brain's anterior region, before interjecting: »Therefore, if this portion (the anterior region) of the cerebrum is wounded, then the internal senses — imagination, memory, thought — suffer; the very will is weakened, and the power

of its determination blunted. This is not the case if the injury is in the back part of the cerebrum» (»The Brain», No. 88). But afterwards he does not bring forward (in »De Cerebro«) any observations which could serve as proof with regard to this. And if one examines the cases he has referred to in his preceding works, one cannot possibly arrive at the localization of the psychic functions which he has here (in »De Cerebro«) sketched; for the evidence concerning the *position* of the injuries in the cortex are entirely too scanty and incomplete. But if we consult the *original descriptions*, we find there many other and more particular data than those quoted by SWEDENBORG when he was only concerned in explaining the function of the cortex as a whole. WEPFER, for instance, reports in his »Historiæ apoplecticorum« concerning the woman seventy years of age, who suddenly *lost the power of speech*, that the cavity, filled with blood, which was found in the cortex at the autopsy, was located in the right hemisphere *just behind the forehead* (»ad frontem fere antrorum«), and that it extended rather far both backwards and upwards; even measurements were given (length 8, breadth 4, depth about 2 uncias). It was also stated that the blood-vessels whose bursting caused bleeding belonged to the antero-lateral branches of the carotid artery in the brain. It is also mentioned that no changes were found in the left hemisphere of the brain; and from the clinical account it appears that even after the stroke the woman was able to move the extremities of the right side.<sup>74</sup>  
 — — — All this indicates quite evidently that the lesion of the cortex was situated in the anterior region of the brain!

And PACCHIONI reports concerning the youth, who was afflicted with the right-sided *facial paralysis*, that even the extremities of the right side were somewhat paralysed, and that the cyst, which at the post mortem examination was found on the left hemisphere, extended *from the crown to the region of the temple* (»a capitis vertice in temporalem regionem«).<sup>75</sup> Thus this case also furnishes an unmistakable indication that the cortical lesion was situated in the anterior region of the brain.

It seems strange that SWEDENBORG did not here supply an account of these interesting and convincing cases, which he nevertheless, as we have seen, was well acquainted with. For his habit is to furnish the

chapters of his works with an introduction in which he reports, often in very detailed form, the statements of the authors upon which he bases his conclusions. Since in the present case such an account is lacking, this may depend: either upon the fact that this last anatomical work of SWEDENBORG, *'De Cerebro'*, was not quite completed and finally edited for the press, or thereon that Dr. RUDOLF TAFEL, who edited the translation which is now accessible in print, excluded it. For Dr. TAFEL says in a note that the introduction to the chapter in question would be introduced into Part II., chapters 1 and 2, but — Part II. was never printed! Since, however, the Royal Swedish Academy of Sciences will publish *'De Cerebro'* in its edition of SWEDENBORG's Scientific works, this question will no doubt be cleared up. But this much is quite clear from what has already been adduced, that the cases of paralysis which SWEDENBORG previously quoted in a brief form are in the original descriptions reported so completely and in such detail that one can without the least doubt localize the cortical lesions reported in those cases in the anterior (superior) region of the cerebrum.

We now pass to an examination of the *anatomical* literature to which SWEDENBORG had access. And, as we shall find, we can here see whence SWEDENBORG derived *material for his detailed doctrine* concerning the function of the brain's anterior region. This becomes evident on comparing SWEDENBORG's mode of thinking of the brain's psychical activity with the descriptions of preceding authors in anatomy.

The group of nuclei, *'corpus striatum'*, in the cerebrum had been an object of special interest for preceding authors.

The Englishman, THOMAS WILLIS, had for example in his *'Cerebri anatome'* (published in 1667) portrayed them as a kind of junction, *'internodes'*, by which the cerebrum coheres with the medulla oblongata; and he pays special attention to it on account of its peculiar structure (*'The Brain'*, No. 476); and he is said even to have attributed to them the *'Sens commun'*.<sup>76</sup>

And the professor in Montpellier, RAIMOND VIEUSSENS, had given in his *'Neurographia universalis'* (published in 1685) a very exact description of the *'corpus striatum'*, (not only of its *'superior nuclei'*):

»Corp. striat. sup. ant.» = Nucleus caudatus and »Corp. striat. sup. post.» = »Thalamus opticus», but also of its lower lateral nucleus = »Nucleus lentiformis») as also of the mighty medullary tract of nerve fibres, i. e., »capsula interna», which passes through the same, and which on the one hand is distributed to the brain, especially to its anterior (superior) region, and on the other hand by means of the nerves radiates into the various parts of the body.

(In order to facilitate orientation we may refer to C. TOLDT: »Anatomischer Atlas», 1899, 8 Lieferung, Fig. 92: »Querschnitt des verlängerten Markes und der Gehirnstiele. Verlauf der Pyramidenbahn von der Pyramidenkreuzung an durch die Pyramide, die Brücke und die Basis des Grosshirnstiels in die innere Kapsel, woselbst sie in den Stiel des Stabkranzes, Pedunculus coronæ radiatæ, eingeht.»)

SWEDENBORG, who had studied and often quoted both WILLIS and VIEUSSENS, likewise attributed a very great significance to the corpus striatum. All the sensory impressions pass through it to the brain, and all the voluntary impulses to motion pass out by the same path. (»The Brain», No. 67). »It is», says he in his figurative way, »in a certain sense, the Mercury of the Olympus; it announces to the soul what is happening to the body, and it bears the mandates of the soul to the body» (»The Brain», No. 67).

And as the corpus striatum lay most immediately under the anterior (superior) region of the brain, and was in close connection with it, so the sensory impressions would for the most part pass to this region, and the voluntary impulses to motion would likewise proceed from it (»The Brain», Nos. 66, 67).

The same VIEUSSENS had furnished a very detailed description of the passage of the nerve tracts in question, which pass through the corpus striatum and capsula interna, and had followed them both upwards towards the hemispheres of the brain and downwards towards the spinal cord. When he followed them upwards, he found that they formed *three regions* in the »centrum ovale»: the *regio superna*, highest up nearest the crown, the *regio media*, in the middle, and the *regio infima*, lowest

down, and consequently nearest the fissure of Sylvius. (R. VIEUSSENS: „Neurographia univ.“, pp. 115 and 117).

In these regions of the cerebral medulla, especially in the highest, VIEUSSENS considered that the soul's activity had its seat: with the help of „spiritus animalis“ the soul here had an opportunity of receiving the sensory impressions, and in the fine and finest nerve fibres there were here formed sensory images, conceptions, (Op. cit. p. 129), here the memory images were preserved, (Op. cit. p. 135), and here the faculty of judgment had its seat, (Op. cit. p. 137), etc.

In these regions, especially in the highest, the will also had its seat and origin, and at its command the „spiritus animalis“ streamed out through the nerves, thus conveying the impulses to motion to the various muscles of the body. (Op. cit. pp. 122, 123, 188, *et seqq.*).

For SWEDENBORG, who had arrived at certainty with regard to the seat of the soul's activity in the cerebral cortex, and not in the cerebral medulla!, and who through MALPIGHI and others had been led to see that *the fibres of the cerebral medulla were continuations of the processes of the cortical elements*, — for SWEDENBORG it naturally lay very near at hand to *follow the fibres of the three regions of VIEUSSENS out to the cortical substance* on the surface of the brain; and so SWEDENBORG has his *three cortical lobes!* And to them, especially to the highest, he could now attribute the source of the soul's life.

When VIEUSSENS followed the nerve tracts of the corpora striata and capsula interna downwards, he found:

that the *fibres of the uppermost region* led down to the *posterior region of the spinal cord*; („ad posticam spinalis medullæ regionem“);<sup>77</sup>

that the *fibres of the middle region*, which were especially coarse and traversed the capsula interna and pons, forming thick tracts, could be clearly followed down into the *anterior portion of the spinal cord*, („in anticam spinalis medullæ partem“), where they came into connection with the anterior origins of the spinal nerves, („ad antica nervorum spinalium principia“), also paying, on their passing through the medulla oblongata, „necessary tribute“, („necessarium vectigal“), as it is expressed, to certain of its nerves;<sup>78</sup> — — See the figure 4! — —

that the fibres of the lowest region were distributed to certain nerves, which proceed from the medulla oblongata, and to some of the anterior origins of the spinal nerves (»quædam illius pars ad quosdam e Medulla oblongata prodeuntes, altera vero ad antica nervorum spinalium principia»).<sup>79</sup>

In SWEDENBORG's time it was, however, known that the muscles which produce the movements of the head and face receive their nerves just from the medulla oblongata and the uppermost part of the spinal cord; and it therefore lay near at hand for SWEDENBORG, when he saw that paralyses arose when certain cortical regions were destroyed, to draw the conclusion, that the muscles and movements which belong to the *face and head*, depend more immediately upon the *lowest* region of the third lobe of the cerebral cortex.

And as it was also known that the muscles of the thorax and abdomen receive their nerves from the superior portion of the spinal cord, whither just the tracts of coarse fibres from the middle region of the brain could be followed, (see figure 4), so SWEDENBORG could likewise draw the conclusion from this that the muscles and movements which belong to the *thorax and abdomen* depend more immediately upon the *middle* region or lobe.

It might now appear tempting to continue the conclusion by connecting the remaining highest lobe and the lower extremity. But probably SWEDENBORG did not consider that he had sufficient ground for this. The description by VIEUSSENS did not here furnish any suitable guidance, for it was possible that the coarse fibres of the middle region continued so far down into the spinal cord that they could innervate not only the muscles of the abdomen but also those of the lower extremity. For this reason SWEDENBORG refrains from localizing exactly the centre of motion of the lower extremity and contents himself with stating in general terms only that this centre might lie above that of the abdomen. He therefore says: »the order seems to be so disposed that — — — the muscles and actions, which are in the *ultimates* of the body, or in the soles of the feet, depend more immediately upon the *highest parts (of the brain)*», whereas concerning the thorax and abdomen he says that they depend upon

the middle *lobe*, and of the head that it depends upon the third *lobe*. (»The Brain», No. 68). I believe that this is the reason why SWEDENBORG's doctrine of localizations as concerns the motor centre of the lower extremity is expressed in such vague terms.

From a comparison of these descriptions by SWEDENBORG and VIEUSSENS we have found that there are such considerable similarities between them that they in many respects agree point for point. And it therefore seems to me rather probable that SWEDENBORG derived his conception of the more detailed localization of the soul's activity from the descriptions of VIEUSSENS.

### THE »CEREBELLULAR THEORY».

But SWEDENBORG was not satisfied with knowing only that the psychical functions arise within certain regions of the cortex of the large anterior region of the cerebrum: but he continued his search for their inmost origin, and thus he came to the conviction that the *psychical processes in reality result from the joint work which is performed by the minute cortical elements*, which SWEDENBORG called »Sphaerulae» or »Cerebellula», that is, the same bodies which we now call the *cortical nerve-cells*. These were the units of which the brain was in reality composed and out of which its actual esse was derived. (See »The Brain», No. 34). It was to these »Cerebellula» that the sensory impressions went, and in these they were perceived and brought to consciousness; it was in these that conceptions, thoughts, judgments, conclusions, came into being. (Œc. R. A. II., No. 191, and »The Brain», No. 98). And this was possible because there were as many kinds of »Cerebellula» as there were kinds of sensory impressions, and that these »Cerebellula» were connected together into groups with different sub-divisions. (Œc. R. A. II., No. 193: VII., chap. XX.). It was also from the »Cerebellula» of the cortex that the determinations and impulses to the various movements of the body emanated. (»The Brain», No. 99). And this was possible because the »Cerebellula» cohered each with its own nerve-fibril, which in their turn innervated the muscle fibre, and that the »Cerebellula» were *arranged*

*into groups, these into greater groups, these into convolutions (gyri), etc., corresponding to muscle fibres, muscles, groups of muscles, etc. (Œc. R. A. II., Nos. 146, 156, and »The Brain«, No. 99). And it is in this connection that SWEDENBORG refers to experiments on animals by which it might be shown which gyre or part of convolution it is, which answers to this or that muscle in the body.<sup>80</sup>*

How SWEDENBORG was able to come to this modern conception ought not to be so exceedingly difficult to understand if we summarize what was already known at that time about these cortical elements and add thereto the conclusions as to the functions of the cortex to which SWEDENBORG had already come.

In SWEDENBORG's time the conception of HIPPOCRATES of the brain as a gland was still generally received. In this one had, however, as MALPIGHI says, »since the time of PICCOLOMINEUS« learned to distinguish between an outer, greyish layer, »cerebral cortex«, and an inner, more pure white mass, the »cerebral medulla«.<sup>81</sup>

Through the microscopic investigations of LEEUWENHOEK (1632—1723) it had further been discovered that the substance of the brain (especially of the cortex) contained, besides a great mass of blood-vessels and very fine fibres, *a numberless mass of peculiar small bodies* of varying size, by him called »globuli«, connected with the vessels and fibres. (See Œc. R. A. II., Nos. 71—75, 112, etc.).

MALPIGHI, (1628—1694), had closely examined these »globuli« and described them as small oval or polygonal »glands«, which were closely surrounded by blood-vessels, and in *their inner central ends sent forth processes forming vessel-like fibres which continued into the cerebral medulla.*<sup>82</sup>

As these fibres or vessels formed small clusters, the little glands hanging on their extreme ends, like »dates on their stems«, as MALPIGHI expresses it, thus formed *small groups*.

Within these groups the cortical elements were, however, *well isolated from each other* by clefts, which indeed sometimes were very small, but could nevertheless be plainly demonstrated with the aid of colouring matter.<sup>83</sup>

The cortical elements taken together formed the winding groups which on the surface of the brain gave rise to the so called gyres.<sup>84</sup>

The profusion of blood-vessels, as was said, LEEUWENHOEK and MALPIGHI had already described as being very great, but RUYSCII (1638—1731) had afterwards by his famous vascular injections found it to be so great that he would not call the cortex a glandular but actually a »vascular» tissue. (Œc. R. A., II., No. 86). Because of the enormous wealth of blood-vessels there was thus carried to the cortical substance, especially to the little follicles, a plenteous quantity of blood, and from this, according to the opinion of that day, the most subtle components of the blood could pass to the cortical elements and thereby be transformed into »spiritus animalis». And finally, the Italians BELLINI, (1643—1704), and ZAMBECCARI had shown by their analyses that the juice of the brain possessed a highly subtle composition, above all a great volatility and lightness, and was exceedingly mobile. (See Œc. R. A. II., Nos. 88, 96, 119). All this SWEDENBORG has himself quoted in his works.

On the basis of these and some other anatomical and physiological data, in conjunction with a number of clinical and experimental observations, SWEDENBORG, as we have before seen, came to the conclusion that it is in the *cortex* that the soul's activity comes into being; but at the same time he concluded that, strictly speaking, the cortical elements were the real work-shops. For he reasoned in the following manner: When the sensory impressions enter the brain, they certainly proceed no further than to the »*Sphaerulae*» of the cortex, since these constitute the beginnings of the nerve and medullary fibres: were they to go further, for instance to the small arteries which surround the cortical elements, or to the membranes of the brain, then they would overstep the boundary, as he says, and leave the actual centre and go out to the more peripheral parts.<sup>85</sup>

SWEDENBORG consequently here followed the same line of thought as his predecessors. DESCARTES supposed that the nerves originated from the wall of the central ventricle of the brain and therefore located the images of sensory impressions, etc., there. VIEUSSENS and others thought that the nerves originate from the centrum ovale, and thus he

placed the psychic activity there. And SWEDENBORG now proceeded in a similar manner when he attributed the psycho-sensory operations to the »Cerebellula». And what other parts of the cortex were better fitted to perform the demanding and ever-shifting psychical labour than the »Cerebellula», to which the life-giving powers of the blood were so plentifully admitted, and in which, according to the testimony of many, the highly subtle nervous fluid was created, whose office it was to communicate the rapid and shifting utterances of the soul's life!

SWEDENBORG's predecessors had thought that the distinctions between the sensory impressions depended partly upon what kind of nerve was affected, and VIEUSSENS had located the images of perception and memory in the nerve-tubes in the centrum ovale, which had the finest caliber. What, then, was more natural than that SWEDENBORG should now locate these images in the »Cerebellula» of the cortex? For what substance of the cortex was better fitted, a more suitable medium to comprehend and distinguish the innumerable shades of the impressions than these myriads of »Cerebellula» — of different sizes, forms and consistency, etc., which were connected each with its own special nerve-fibril and so well distinguished from their neighbors! And at the same time they were connected with the other »Cerebellula» into groups of different kinds, by which the psychical elaboration of the impressions was made possible.

On similar grounds SWEDENBORG supposed that the psycho-motor labour was performed by the »Cerebellula», from which the nerves derived their origin. And here we may recall that VIEUSSENS had already *connected certain groups of nerves with certain bundles of medullary fibres*, and that MALPIGHI had shown how *bundles of fibres of the cerebral medulla corresponded to smaller and larger groups of cortical elements*, each one of which, hanging by its fibre, formed the different *gyres of the brain*. If we consider this, then we can easily understand how SWEDENBORG, with his view of the cortex, could divine the correspondence between the components of the convolutions and the muscles.

It is interesting to here follow him in his line of thought and to see how well he understood how to combine his anatomical and clinical experiences: With the magnifying glass one can see how the nerve-

fibres spring forth from the cortical substance like a brook from its source; if now the cortical substance be injured (as in the case of certain brain diseases, and which one may clearly see upon autopsy), then the injury is spread through the nerves connected with the cortex and at last all the way down to the muscles, and that, he thought, explained the motor disturbances.<sup>86</sup> And further . . . when one or several of the 'Cerebellula' of the cortex are destroyed, then the damage is spread more immediately only to their proper nerves and muscles.<sup>87</sup>

In this manner did SWEDENBORG synthesize his anatomical, pathological-anatomical and clinical experiences and extracted from them his conclusions, and by them he arrived at essentially the same conception, as our times, of the principles of the nervous system, its cellular structure. He did not indeed employ the same nomenclature for the nerve-cells and their long processes, as we do; but the matter itself: the nature of the nerve-cells as elementary organs of the nervous system, the intimate connection between the nerve and its cell-body, indeed even its dependence upon it in regard to nourishment, etc., he was able to clearly grasp in this way, — and this more than a century before our modern theory of these relationships, the 'neurone-theory' saw the light.

#### CONCLUDING SUMMARY.

I hereby conclude my presentation of the grounds upon which SWEDENBORG appears to have founded his doctrine of the cerebral cortex as the seat of the soul's activity.

I. It has here been my endeavour to show, that his *first* general statement that the centres of the psychical functions are to be found in the cortex was a conclusion, which he derived from three premises, secured in different ways:

The *1st* premise was a conclusion drawn from the clinical observations, post mortem discoveries and results obtained from experiments on animals, which he had collected from literature;

The *2nd* premise was a summing up of the comparatively recent discoveries in microscopic cerebral anatomy, and

The *3rd* was an hypothesis, concerning the continuous connection between the cortical elements and the fibres of the cerebral medulla, by which an easy communication was established between those elements and the distributions of the nerves in the various parts of the body. In his conclusions from these premises SWEDENBORG had some guidance in preceding authors, who placed at least the sensory function in a certain connection with the cortical substance.

II. His second statements, his essential *doctrine of localization*, showed in many points a great agreement with that presented by VIEUSSENS, but also contained important differences, which partly rested upon the conclusion to which SWEDENBORG had previously come, concerning the importance of the cortex for the psychic life, partly depended upon the new point of view concerning the correspondence of the cerebral regions to those of the body, to which he had arrived in his work supported by clinical results. The *detailed* doctrine of localizations seems to have been constructed with the assistance of VIEUSSENS' detailed statements concerning the connection of the nerves with the various regions of the cerebral medulla.

III. His third statement, his — so to speak, »*Cerebellular theory*», that the »Cerebellula» were the units of which the brain was in reality composed, and that the function of the cortex was essentially the summing up of the activity of the »Cerebellula, and that the »Cerebellula» were connected with one another into various kinds of groups, corresponding to the various kinds of perceptions and to the different movements of the body, etc., this was grounded in part upon the discoveries of MALPIGHI and others and their detailed descriptions of the structure and situation of the cortical elements and their connection with each other, in part upon SWEDENBORG's clinical experiences and his own previously drawn conclusions, which be further followed up.

The first two statements have in our time been embraced with the liveliest interest and essentially corroborated. And as concerns the third, the same applies in part; but how great the validity of this statement is, it is for the future to decide.

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Consequently SWEDENBORG arrived at almost the same result as that to which our own day has attained, although in a partly different manner. Our times have had the assistance of exact methods of investigation and of a most highly developed technique. In SWEDENBORG's time the research method of microscopical anatomy and experimental physiology were yet in their cradle; and the two branches of science, medicine and pathology, which afterwards with the greatest interest have taken part in the investigation of the function of the cortex, had then hardly as yet turned their attention thither. As to how SWEDENBORG nevertheless succeeded in winning such rich and beautiful results in this field, and how well he employed the widely spread literature in question, I have attempted to show in this my presentation by tracing his path through the folios of the old authors and indicating the places where he gathered the material for his doctrinal structure and the premises for his conclusions. Finally, however, it should be emphasized that, when SWEDENBORG collected his facts from the many separated fields of literature, he found them not at all presented in the large works as important »chief subjects«, or even as lying plainly at hand. No, he was often, so to say, obliged to dig out his material from a chaos of erroneous observations, false interpretations and curious conceptions; and afterwards he had to still further sift and elaborate it, before he could draw his conclusions out of it.

I view of all this one must say that it was in truth a *work of genius* to search out of such a chaos the guiding threads which were concealed within it, and that, in spite of their imperfection in many points, nevertheless to be able to find so much of the truth!

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## NOTES.

<sup>1</sup> See the treatise of ANDERS RETZIUS on: »The Origin and Development of Anatomy in the Scandinavian North», which he delivered as an address on the occasion of his leaving the presidency of the Royal Swedish Academy of Sciences on April 9<sup>th</sup>, 1845. See also GUSTAF RETZIUS: Preface to »EMANUEL SWEDENBORG's Scientific Works», edit. by the Royal Swedish Academy of Sciences, Vol. I., 1907, p. V., *et seqq.*, and ALFRED H. STROH, M. A.: »Some testimonies concerning SWEDENBORG, the Scientist», Stockholm 1909, p. 10.

<sup>2</sup> In an address before the Royal Swedish Academy of Sciences at Stockholm in connection with a reference to SWEDENBORG's work: »De Cerebro», which had just appeared in the English translation by DR. RUDOLF TAFEL; See GUSTAF RETZIUS: Op. cit. p. VI. and ALFRED H. STROH: Op. cit. p. II.

<sup>3</sup> See an address of MAX NEUBURGER concerning »Swedenborg's Beziehungen zur Gehirnphysiologie», delivered before the »Versammlung deutscher Naturforscher und Ärzte», Hamburg, 1901.

<sup>4</sup> See the article by C. G. SANTESSON concerning SWEDENBORG in »Nordisk Tidskrift», 1904, No. 5.

<sup>5</sup> See an address of GUSTAF RETZIUS as president of the »Versammlung der Anatomischen Gesellschaft», Heidelberg, 1903; and also his preface to the edition of EMANUEL SWEDENBORG's Scientific Works, which the Royal Academy of Sciences began to publish in 1907; and the references by the same author to SWEDENBORG'S statements concerning the anatomy and physiology of the brain in the Croonian lecture delivered by him in London, in the year 1908.

<sup>6</sup> See the address of J. J. BERZELIUS at the meeting of Scandinavian Natural Scientists in 1842 concerning: »The rise of the Scandinavian shore above the level of the surrounding ocean» etc., quoted from ALFRED H. STROH: Op. cit. p. 6.

<sup>7</sup> See the address of A. E. NORDENSKIÖLD before the Royal Academy of Sciences on March 26<sup>th</sup>, 1888, quoted from A. H. STROH: Op. cit. p. 6.

<sup>8</sup> See A. G. NATIÖRST's introduction to the edition of SWEDENBORG's Scientific Works of the Royal Academy of Sciences, Vol. I., 1907.

<sup>9</sup> See »Vierteljahrsschrift der Astronomischen Gesellschaft», Part 14, 1879, quoted from A. H. STROH: Op. cit. p. 8.

<sup>10</sup> See S. ARRHENIUS' introduction to the edition of SWEDENBORG's Scientific Works of the R. Acad. of Sciences, Vol. II., 1908.

<sup>11</sup> See GUSTAF RETZIUS: Preface to »E. SWEDENBORG's Scientific Works», edit. by the R. Acad. of Sciences, Vol. I., 1907, p. V. *et seqq.*

<sup>12</sup> EMANUEL SWEDENBORG was born at Stockholm, January 29<sup>th</sup>, 1688; matriculated at the University of Uppsala and »Västmanlands-Dala-nation», 1699; Diss. cum consensu Fac. Philos. publico examini submissa, Upsaliæ, 1. Junii, 1709; appointed assessor extraordinary in the Royal College of Mines, 1716; ordinary assessor in the same College, 1724; retired from the assessorship, 1747; died in London, March 29<sup>th</sup>, 1772. His name was SWEDBERG until the year 1719, when he was ennobled and his name changed to SWEDENBORG.

<sup>13</sup> Epistola Eman: Swedberg<sup>ii</sup> ad Ericum Benzelium, Londini, Oct., 1710. See EMANUEL SWEDENBORG: Opera quædam aut inedita aut obsoleta de rebus naturalibus, nunc edita sub auspiciis Regiæ Academiæ Scientiarum Suecicæ, I. Geologica et Epistolæ, Edit. ALFRED H. STROH, Holmiæ, 1907, p. 206 *et seqq.*

<sup>14</sup> Epist. Em. Sw. ad E. Benz., London, April, 1711, see Op. cit. p. 208 *et seqq.*

<sup>15</sup> Epist. Em. Sw. ad E. Benz., London, Augusti, 1712, see Op. cit. p. 218 *et seqq.*

<sup>16</sup> Epist. Em. Sw. ad E. Benz., Paris, Augusti, 1713, see Op. cit. p. 222 *et seqq.*

<sup>17</sup> Epist. Em. Sw. ad E. Benz., Rostock, September, 1714, see. Op. cit. p. 224 *et seqq.*

<sup>18</sup> Suggestions for a Flying Machine by EMANUEL SWEDENBORG, translated from the original Swedish by HUGO LJ. ODHNER and CARL TH. ODHNER, published by the Swedenborg Scientific Association, Philadelphia, Pa., 1910.

<sup>19</sup> Dædalus Hyperboreus, Eller Några Nya Mathematiska och Physikaliska Försök och Anmerckningar: Som Wälborne Herr Assessor Polhammar och Andre Sinrike i Swerige Hafwa gjordt Och Nu tijd efter annan til almen nyttta lemma. Printed in Upsala (and Skara), 1716—1718. Preface by EM. SVEDBERG, Stockholm, Dec. 23<sup>rd</sup>, 1715.

<sup>20</sup> »Förslag til vårt Mynts och Måls Indelning, så at Rekningen kan lettas och alt Bråk afskaffas». Stockholm, Kongl. Boktryckeriet, 1719, 8 pp. 4:o. See ALFRED H. STROH and GRETA EKELÖF: Chronological list of the works of Emanuel Swedenborg, dedicated to the Swedenborg Society by the Royal Swedish Academy of Sciences, Uppsala and Stockholm, 1910, pp. 17 and 19.

<sup>21</sup> Eman. Swedbergs Assess. i Kongl. Bergz Coll. Försök Att finna Östra och Westra Lengden igen igenom Månan, Som Til the Lärdas ompröfwande framstelles. Upsala, 1718, See ALFR. H. STROH and G. EKELÖF: Op. cit. p. 17. See also the letters of Eman. Swedberg ad Ericum Benzelium in the Swedenborg edition of the Acad. of Sciences, Vol. I.

<sup>22</sup> See E. LILJEDAHL: »Swedenborg», Stockholm, 1908; and HJ. HOLMQUIST: »Från Swedenborgs ungdom och första stora verksamhetsperiod», Bibelforskaren, 1909, No. 3.

<sup>23</sup> See also ALFR. H. STROH and G. EKELÖF: Chronological list of the works of E. Swedenborg, pp. 15 and 16. The titles of the three pamphlets are in English: »On the way to improve commerce and manufactures», »Memorial on the institution of saltboileries in Sweden», »On the utility and necessity of instituting an observatory in Sweden».

<sup>24</sup> »Om Watnens Högd och Förra Werldens starcka Ebb och Flod, Bewjs utur Swergie». (Stockholm, 1719; see also Acta Literaria Sueciæ Upsaliæ publ. 1720, pp. 5—11). Reprinted in the edition of Swedenborg's Scientific works, publ. by the R. S. Acad. of Sciences, Vol. I., pp. 1—27.

<sup>25</sup> See concerning this the above-named work by HJ. HOLMQUIST, in which he says p. 223 concerning SWEDENBORG's method of research: »SWEDENBORG himself indicates the scientific method which he followed: first, the collecting of as many experiments and investigations as possible, afterwards the working over of these according to the laws of geometry, and lastly, speculation, hypotheses: 'as long as proofs are lacking, principles may not be accepted and hypotheses defended, as they then deserve better the name of fantasies than of principles'. 'Experientia, geometria et facultas ratiocinandi', experience, geometry and reason, were the foundations of SWEDENBORG's work both within the world of nature and that of spirit.»

<sup>26</sup> See »Œconomia Regni Animalis», Vol. I., No. 360, where Swedenborg mentions Parts IV., V., VI. of the Œc. R. A.

<sup>27</sup> Œc. R. A. Vol. III., »De Fibra», translated into English by Rev. Prof. ALFRED ACTON in »New Philosophy».

<sup>28</sup> See Œc. R. A. Vol. II., Nos. 71—75, 76—82, 112; III. No. 59, etc.

<sup>29</sup> See Œc. R. A. Vol. II., Nos. 100, 101, 191; »Quod sensationes externae non ad ulteriores metas quam ad sphaerulas corticales pertingant, id satis in confirmato est, quando hae fibrarum nervearum et medullarium sunt principia»; and 113, 130, 140, 141, etc. See also »The Brain» No. 98.

<sup>30</sup> As observed in Quain's »Elements of Anatomy», Tenth edition, edit. by E. A. SCHÄFER and G. D. THANE, Vol. III., Part. I, p. 39: »The term medulla oblongata, as employed by WILLIS and VIEUSSENS, and by those who directly

followed them, included the crura cerebri and pons Varolii, as well as that part to which by HALLER first, and by most subsequent writers, this term has been restricted.»

<sup>31</sup> See *Œc. R. A.* Vol. II., Nos. 83—85, 91, 93, 95, 114, 140: »Proinde cum totidem origines motus sunt, quot sphaerulae istius substantiae;» and 144, 146: »Sic distinctissime quaevis (sphaerula) suam fibrulam animat & usque ad ejus finem in fibram corporis motricem influit;» 157 and 191—194—95, 202 etc. See also »The Brain», No. 399.

<sup>32</sup> So, for example, in *Œc. R. A.* Vol. II., No. 100: .... »quod Cortex sit principalis totius Cerebri substantia; in ipso termino primo Fibrarum et ultimo Arteriarum sita; See also *Œc. R. A.* Vol. II., 111—116, 133, 134, 138, 152, 197, 290, etc., or, for example, *Œc. R. A.* III., No. 127, fin., and No. 404, where we read as follows: »Ex anatome Cerebri id constat, quod Cerebrum, seu substantia ejus corticalis, quae proprie cerebrum audit, sit *Sensorium commune*, nam quinque organa suos sensus externos ad corticem ut ad suum sensorium commune et unicum internum referunt. Cerebrum corticale etiam est *Motorium commune voluntarium*, quicquid enim agendum est mediantibus nervis et musculis, id praevia voluntate a cerebro determinandum est.

<sup>33</sup> *Œc. R. A.* II., 107: »Partes hujus substantiae — — — merentur *Organa Sensuum interiorum* et Cerebellula nuncupari, nam media substantia medullari et sanguine ab Organis externis alluentes modos et tactus recipiunt, et ad judicem animam referunt.» See also *Œc. R. A.* 191, 192, *Œc. R. A.* II., 195: — — »Substantiae Corticales totidem sunt Cerebellula, — — ; singula enim sensorium est in particulari, quale est Cerebrum in communi.»

<sup>34</sup> *Œc. R. A.* II., 193: »Haec minime effectum consequerentur, — — — nisi partes substantiae *Corticalis inter se, atque in gradus et series sint divisae, in quales sunt modificationum causae: seu nisi series substantiarum corticalium sint uti series sensationum;* nisi sphaerularum Corticis perfectissima sit varietas harmonica, ita ut nulla earum, praeter qua essentialia et attributa, alteri sit simillima.» For the same see also »Regnum Animale», VII., chap. XX; *Œc. R. A.* II., No. 307: »Ex lustratione ipsius Cerebri appareat, quod substantiae corticales ita Sapienter sunt ordinatae, ut cuilibet sensationi externae ad amussim correspondeant; nam dictae substantiae, ut unitates glomatim in quendam numerum coalescent, et hi glomuli tanquam novae unitates in congeries adhuc maiores, et hae in maximam, quae est ipsum Cerebrum: singulae partitiones discriminatae sunt per rimas, sulcos et anfractus, et consertae per vasa et productiones meningeas, sic ut quasi sint numeri unitatum in analogiae formam redacti, prorsus ut decet sensorium commune, quod recepturum sit omnem spe-

*ciem sensationis externae, distinctum suum visum, distinctum auditum, gustum et olfactum.* *Œc. R. A. II.*, chap. XX.

<sup>35</sup> *Œc. R. A. II.*, No. 192, »Ex anatome Cerebri in ipsius oculi luce est, quod *radii visuales* medio nervo optico *influant in thalamos nervorum optico-rum*, et abinde per collectas e toto Cerebro, perque Fornicis basin transmissas, et thalamis superinstratas fibras, quaquaversum in *corticem* diffundantur.»

<sup>36</sup> *Œc. R. A. II.*, No. 192. — — »quod *subtiles tactus membranae Olfactoriae* cavitates labyrinthicas narium investientis, et inde oriundae subtile tremiscentiae aut modificationes per laminam cribrosam et processus mammillares in *Corpora striata*, aut in medullam totius centri ovalis emitentes non desinant nisi in peripheriam fibrarum, seu in *ambitum corticalem*;» See also II., 38—42, where the processus mamillaris is supposed to mediate a reflex action from the sense of smell upon the muscles of breathing.

<sup>37</sup> *Œc. R. A. II.*, No. 101: — — »totidem origines motus sunt, quot sphaerulae illius substantiae (corticis); II., 140, 153, etc.

<sup>38</sup> *Œc. R. A. II.*, No. 146, »Sic distinctissime quaevis (Sphaerula) suam fibrulam animat, et usque ad ejus finem in fibram corporis motricem influit»; see also II., 135, 147, 150, 156: »Ex his . . . . fluit consequens de singulis Cerebellulis . . . ., quod vitiato uno aut pluribus . . . . contagium se non latius quam in appensa fibras et subjectos musculos immediate extendat.» And III., 59, 127, at the end, and 197.

<sup>39</sup> *Œc. R. A. II.*, No. 147: »Sphaerulae illum sortitae sunt in Cerebro ordinem et situm, ut *singulae aut plures simul, aut omnes in communi* queant systolen suam et diastolen perficere». *Œc. R. A. II.*, No. 156: »Quare ita compaginatum est Cerebrum, ut totum queat alterna vertigine auferri, utque solum ejus medietas aut semiglobi Haemisphaerium; aut solum plures aut una circumgyratio; aut utmodo hujus glomus, minor congeries, aut pars.» The same in »The Brain», No. 104 c.

<sup>40</sup> *Œc. R. A. I.*, No. 505: »Ergo inquirendum venit, qui tori corticei his aut illis musculis in Corpore correspondent; quod fieri non potest nisi per experientiam in vivis Animalibus; per punctiones, sectiones et compressiones plurium, perque inde in Corporis musculis redundantes effectus.»

<sup>41</sup> *Œc. R. A. II.*, Nos. 151, 157: — — — licet *ipsa fibra Cerebri* non agat motricem in musculis, agit tamen in utraque illa *Medulla*, quarum fibras ad sic non aliter agendum disponit, uti ab Anatomia Cerebri tam humani, quam animalium brutorum, imo insectorum, clare colligitur: idque ob rationem, ut *Cerebri Voluntarium* abeat in spontaneum et naturale mediis *Medullis*, ne toties in particulares profundas motiones auferatur, quoties actio semel incepta ex consueto continuanda sit: id ejus sublimiorum officiorum administrationem toties

alias interturbaret, et in Homine analyses rationales, quae quietiorem Cerebri statum poscunt: quare *ut primum actio voluntaria poscit seriem agendorum continuam, Cerebrum annuet et consentiet, tum et actionis actualitatem producit: Sic ejus est causa principalis, Medullis autem incineratis injuncta secundaria.*» See also I., No. 574: — »origo secundaria vel causa intermedia actionum Voluntiarum in Spontaneas abeuntium sit in Medulla Spinali et oblongata.»

<sup>42</sup> *Œc. R. A. II.*, No. 107: »Partes hujus substantiae ex eadem ratione merentur *Organa Sennuum interiorum*, et Cerebellula nuncupari». See also II., No. 191, etc.

<sup>43</sup> *Œc. R. A. II.*, No. 159: »Id jam extra omnem dubitationis aleam ponimus, quod *substantia corticalis* sit determinans, licet non omnium primum, actionum Corporis, quia determinans est fibrarum, et fibrae muscularum, a quibus actio». — — — II., No. 160: »Sed hae *substantiae corticales* licet sunt determinantes actionum sui Corporis, respective tamen sunt modo *subdeterminantes et mediantes*, quibus respondent subdeterminantes in Corpore, quae sunt fibrae motrices.» See also II., No. 204.

<sup>44</sup> *Œc. R. A. II.*, No. 277: »— — — dicere quod *Anima* sit supra mentem intellectualem, — — —» See also II., No. 280. II., No. 160: »Per illas (*substantias corticales*) etenim determinatur in actum voluntas, cuius principium altius est rimandum. — — — requiritur vis altior, sublimior, principalior, et universalior, in qua sit principium voluntatis, qua his mediis determinatur in actum. Proinde est fluidum spirituosum, in quo est vita, et proinde anima.»

<sup>45</sup> *Œc. R. A. II.*, 285: »Ex his jam sequitur, quod *Anima* sit, quae intelligit, cogitat, judicat, vult, desiderat, imaginatur, cupit, reminiscitur, videt, audit, gustat, odorat, sentit, loquitur, agit, — — —.» See also II., 287.

<sup>46</sup> *Œc. R. A. II.*, No. 160, 161: »Et haec denique concludit, quod sit *anima*, quae huic fluido (*spirituoso*) inest, cuius est determinare in actum.» II., 165. II., 303: »Ipsum Fluidum Spirituosum est substantia eminenter organica suae Animae; uti Oculus est organum visus, Auris auditus, Lingua gustus, Cerebrum perceptionis omnium»; etc. See also »The Brain», No. 7.

<sup>47</sup> See for example *Œc. R. A. II.*, No. 246: — — — »sic etiam quod hoc Fluidum sit Spiritus et Anima sui Corporis». — — — *Œc. R. A. III.*, No. 317: »*Anima* est purissima essentia animalis, caelestis et spiritualis, quae fibram simplicem excitat et simul sanguinem tam candidum quam rubrum ingreditur.»

<sup>48</sup> See also *Œc. R. A. II.*, No. 348: »Ex his jam praemissis usque ad fidem intellectus demonstrari potest, quod *Fluidum Spirituosum humanum immunissimum* sit ab omni injuria contingentium in regione sublunari; nec extinguibile, sed *immortale*, tametsi non per se, *post casum sui Corporis*. Quod exsolutum a vinculis et laqueis terrestrium in omnem sui Corporis formam coaliturum sit

et victurum vitam omni imaginatione puriore. Tum quod nulla sit actiuncula ex consulto, et nulla vocula ex consensu, in vita ejus corporea, edita, quae non affulgente luce sapientiae, inhaerenter designatae, tunc ante ejus conscientiae judicium, distincte compariturae sint».

<sup>49</sup> *Œc. R. A. II.*, No. 303: »usque eodem recidit, sive memoratum fluidum dicimus Spiritum aut Animam, sive ejus facultatem sibi repraesentandi universum et intuendi fines, nam unum non concipi potest, quia non datur sine altero.»

<sup>50</sup> J. J. GARTH WILKINSON has published Part I. in an English translation in 1843, and Parts II. and III. in 1844, London.

<sup>50 b</sup> »Regnum Animale», Pars quarta: »De Sensibus», publ. by IM. TAFEL, London, 1848; transl. into English by ENOCH S. PRICE in »New Philosophy»; »R. A.», Pars septima: »De Anima», publ. by IM. TAFEL, Tübingen and London, 1849; transl. into English by FRANK SEWALL, New York, 1887 and 1900.

<sup>51</sup> The words enclosed in parentheses have been added by the author of this paper to make the meaning more clear, and are unmistakeably inferred from the connection.

<sup>52</sup> As Professor G. RETZIUS also says in his »Croonian lecture», delivered in London, 1908: »The theses cited [especially those concerning the localization of the motor centres in the cerebral cortex] are drawn up with such precision by SWEDENBORG that they cannot possibly be based on divination only, but must rest upon a real grasp of natural phenomena as well as on actual experiments and dissecting work».

<sup>53</sup> See »Œconomia Regni Animalis», I., Nos. 559 *et seqq.*; also 571 and 572, and R. VIEUSSENS: »Neurographia universalis», Lugduni, 1685, pp. 123, 124, etc.

<sup>54</sup> See »Œconomia Regni Animalis», I., Nos. 559 *et seqq.*, as also R. VIEUSSENS: »Neurographia universalis», Lugduni, 1685, pp. 123, 124, *et seqq.*

<sup>55</sup> See BOERHAAVE: »Institutiones medicae», Lugduni Batavor. 1720, No. 415: »Ergo musculi voluntarii nervos habent ultimo oriundos a cerebro. Illi vero, qui spontaneis, vitalibusque motibus serviunt, a cerebello nervos accipiunt.»

<sup>56</sup> See TH. WILLIS: »Cerebri Anatome», Amsterdam, 1667, pp. 73—74: »Cerebrum motuum et conceptuum omnium origo et fons. Sensus et motus, item passiones et instinctus mere naturales, licet a Cerebro quadantenus dependent, tamen proprie in Medulla oblongata et Cerebello aut perficiunter aut ab iis procedunt.

<sup>57</sup> See *Œc. R. A. III.*, No. 404, etc.: »Medulla oblongata — — — sensorium et motorium commune tam Cerebri quam Cerebelli, sed secundarium et instrumentale superius. Medulla spinalis similiter — — — sensorium et motorium commune, sed secundarium et instrumentale inferius.»

<sup>58</sup> *Œc. R. A.*, III., No. 133: »Substantia — — — corticalis est ipsum Cerebrum seu Sensorium — — — commune»; No. 404, etc.

<sup>59</sup> See R. DESCARTES: »Tractatus de homine», Lugd. Bat. 1662, pp. 77, 81, 82; 32, 67 etc.: 72, 79 etc.

<sup>60</sup> See H. BOERHAAVE: »Institutiones medicae», Lugd. Bat. 1720, p. 253: »Sensorium commune est pars cerebri, — — —, adeoque, ut appareat, medulla cerebri in capite;» and BOERHAAVE: »Praelectiones academicæ», (published by HALLER), Göttingen, 1743, p. 451: »Haec ergo sedes animae non est in pineali glandula, uti CARTESIUS voluit, — neque est in medulla spinali, neque est in cerebello, verum in fornicata medulla circumstante cavitatem ventriculorum cerebri.»

<sup>61</sup> See CASP. et THOM. BARTHOLIN: »Instit. anatom.», 1641, p. 265: »Putamus enim in Cerebro proprie dicto, vel cortice servari spiritum animalem pro sensu, in medulla vero tota tam quoad caput quam quoad caudam, reservari spiritum pro motu.»

<sup>62</sup> See THOMAS WILLIS: »Cerebri Anatome», 1667, pp. 76, 77: »Etenim existimare fas est, spiritus animales — — in corticali cerebri substantia procreari» — — »hæ partes medullares spirituum animalium exercitio et dispensationi — — inserviunt;» and J. J. WINSLOW: »Exposition anatomique — — », 1732, IV., p. 210: »WILLIS nous donne un système tout-à-fait particulier. Il loge le sens commun dans le corpus striatum ou corps rouge, l'imagination dans le corps callosum, et la mémoire dans l'écorce ou dans la substance grisâtre qui enveloppe la blanche.»

<sup>63</sup> See M. MALPIGII: »Opera Omnia», 1686—87, Tom. II., p. 85: »Suspiciari possumus minimis hisce glandulis ex delato sanguine separari, recolligique particulas illas a natura ad promendum instrumentaliter sensum destinatas, quibus per nervorum tubulis delatis continuatae partes inbibantur et turgeant.»

<sup>64</sup> See MALPIGHI: »Opera Omnia», 1686—87, Tom. II., De Cerebri cortice, pp. 78 *et seqq.* »In — — cerebro corticem affusum minimarum glandularum proventum et congeriem esse deprehendi: hæ in cerebri gyris et protractis veluti intestinales, ad quæ desinunt albæ nervorum radices, vel inde, si mavis, oriuntur — — —;» and SWEDENBORG: *Œc. R. A.* II., Nos. 76—82, 112, 114 etc.

<sup>65</sup> See BOERHAAVE: »Institutiones medicae», 1720, No. 266: »folliculi illi minimi glandulosi emittunt tenues fibras, albas, compactas quibus adenutis fit callosum, medullosumque corpus» — — —; No. 274: »fibras has canaliculos tenuissimos pervios esse, qui in se excipient humorem corporis humani omnium quidem subtilissimum, qui fabrica mirifica corticis praeparatus, secretus atque vi in has fistulas impulsus est, ex omni quidem parte hujus in medullam oblongatam collectus; see also No. 263; No. 284: »fibrillas nerveas humorem medullæ — — ad omne punctum totius corporis distinctissimis viis deferre.» — — —

<sup>66</sup> »Nisi mutua sit connexio et perpetua communicatio substantiae medullaris qua fibrillas et manipulos intra thecam vertebralem et cranium, undecunque ducitur ad corticem cerebri. — — —» (Œc. R. A. II., No. 193; See also No. 115).

<sup>67</sup> See above CASP. and THOM. BARTHOLIN: »Inst. Anat.», 1645, p. 265.

<sup>68</sup> See H. BOERHAAVE: »Inst. Med.», 1720, N. 574. or 274.

<sup>69</sup> See above A. v. HALLER: »Elem. Physiol.», 1762, IV., p. 392.

<sup>70</sup> Œc. R. A. loco cit. and II., 88. See also A. PACCHIONI: »Opera», Ed. quarta, Romæ, 1741, p. 112.

<sup>71</sup> Se BOERHAAVE: »Instit. med.», 1720, No. 570, 574. The edition used by SWEDENBORG was printed 1727.

<sup>72</sup> »Nempe in sensorio coimmuni distinctas loco provincias esse pro diversis sensibus, uti cuilibet sensui suum externum proprium organum datum est.» BOERHAAVE: »Prael. acad.», published by HALLER 1743, Vol. IV., p. 435. See also BOERHAAVE: »Inst. med.», 1720, No. 568.

<sup>73</sup> These lobes are, as he says, »marked out and encompassed by the carotid artery, a statement by which he probably means the same as RIDLEY, when the latter says of the whole anterior region that it is marked out, as it were, by two branches of the carotid artery, one at the front and one at the side, i. e., *Arteria cerebri anterior* and *Arteria cerebri media*.

<sup>74</sup> J. J. WEPFER: »Observationes anatomicæ ex cadaveribus eorum, quos sustulit Apoplexia». Amstelædami, 1681, pp. 5—11, Case II.

<sup>75</sup> See A. PACCHIONI: »Opera», Ed. quarta, Romæ, 1741, p. 112.

<sup>76</sup> See J. B. WINSLOW: »Expositon anatomique de la Structure du corps humain. Paris, 1732, IV., p. 210. With WILLIS one also finds the same subdivision of the hemispheres of the brain into an anterior and a posterior »province», as that employed by SWEDENBORG.

<sup>77</sup> VIEUSSENS: »Neur. univ.», pp. 115, 117, and Tab. X.

<sup>78</sup> Op. cit., pp. 115, 117, and Tab. XVI.

<sup>79</sup> Op. cit., pp. 115, 117 and Tab. XV.

<sup>80</sup> Œc. R. A. II., No. 153: »Experientiae est et temporis, ut evestigetur, qui gyrus et qui serpens tumulus in cerebro hunc aut illum musculum ut correspondentem suum in corpore respiciat. 'Cuniculos cerebri serpere, per autopiam deprehenditur' ait Clar. PACCHIONUS, BELLINUS et alii plures.»

<sup>81</sup> See MALPIHIGI: »Op. omnia», II., De Cerebro, p. 2. and SWEDENBORG: Œc. R. A., II., Nos. 82, 58, etc.

<sup>82</sup> MALPIHII: »Opera omnia», 1686—87, II., De Cerebri cortice, p. 78, and SWEDENBORG: Œc. R. A., II., Nos. 76—82, 112, 114, etc.

<sup>83</sup> MALPIHII: Op. cit. p. 78: »Harum glandularum distinctionem affuso atramento (ink) et leviter gossypio deterso, videbis, intercepta enim spatia ita

denigrantur, ut circumscriptas glandulas facilius exhibeant.» See also *Œc. R. A.* No. 76.

<sup>84</sup> MALPIGII: Op. cit., p. 79: »Corticale hae glandulae tortuose locatae exteriores cerebri gyros componunt, et ex orientibus inde medullaribus fibris seu vasculis appenduntur». See also *Œc. R. A.*, II., No. 76.

<sup>85</sup> See *Œc. R. A.*, II., No. 191: »Quod sensationes externæ non ad ultiores metas quam ad sphaerulas corticales pertingant, id satis in confirmato est, quando hae fibrarum nervearum et medullarium sunt principia, ultra quae si progrederentur, ut si in arteriolas aut meninges, tunc praescriptos terminos superscanderent et a centris in remotiores peripherias se conjicerent.»

<sup>86</sup> See *Œc. R. A.*, III., N:o 127: »Si enim vivum corticem in apertis cerebris lente microscopica, sive delineatum ex vivo contemplamur, evidenter conspicitur, quomodo fibra ex illo procedat, et tanquam rivulus ex fonticulo scaturiat; id etiam in hydrocephalis, apoplecticis, catalepticis, paralyticis, maniacis, motibus convulsivis et spasmis cynicis vexatis confirmatur, nam ipsa labes substantiæ eorum corticalis post mortem deprehensa in continuas fibras, et tandem in musculares, unde prodeunt actiones et inconcinni motus, derivatur. — — Ergo, quia substantia corticalis est parens fibrarum, sequitur, quod cerebrum non nisi quam in hac sua substantia incipiat cerebrum esse, quatenus ibi est receptaculum sensationum seu sensorium commune, et simul principium actionum, seu motorium commune.»

<sup>87</sup> See *Œc. R. A.*, II., No. 156: »Vitiato uno cerebellulo aut pluribus in toto, contagium se non latius quam in appensas fibras et subjectos musculos immediate extendat.»









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